REPORT RESUMES

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SYSTEMS ANALYSIS AND SYNTHESIS APPLIED TO OCCUPATIONAL INSTRUCTION IN SECONDARY SCHOOLS.

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GOAL OF THIS STUDY WAS TO DETERMINE THE FEASIBILITY OF DEVELOPING A MODEL TO DESCRIBE "REAL-LIFE" FEEDBACK SIGNAL PATHS FROM OUTSIDE THE SECONDARY SCHOOL OR SCHOOL DISTRICT TO AN OCCUPATIONAL TEACHER. AFTER A REVIEW AND EVALUATION OF THE LITERATURE IN SYSTEMS ANALYSIS AND SYNTHESIS SINCE 1914, IT WAS CONCLUDED THAT ATTENTION SHOULD BE DIRECTED TO SYSTEMS THEORY IN DISCIPLINES OTHER THAN EDUCATION. DATA USED TO SYNTHESIZE A FLOW CHART MODEL WAS COLLECTED IN INTERVIEWS WITH EDUCATORS, OCCUPATIONAL DIRECTORS, STUDENTS, AND OTHER PROFESSIONALS, BUT THE TOTAL NUMBER OF INTERVIEWS IS NOT REPORTED. THE CYBERNETIC MODEL INCLUDES 49 CLOSED-LOOP FEEDBACK SIGNAL PATHS, EACH IDENTIFIABLE IN TERMS OF 5 CHARACTERISTICS WHICH IN TURN AFFECT INSTRUCTOR PERFORMANCE. THE MODEL WAS SHOWN TO BE FEASIBLE AND APPLICABLE TO REAL-LIFE. CONTINUING REFINEMENT OF THE LOOPS, USING MATHEMATICAL TECHNIQUES AND REAL-LIFE EXPERIENCES, IS RECOMMENDED. (LH)

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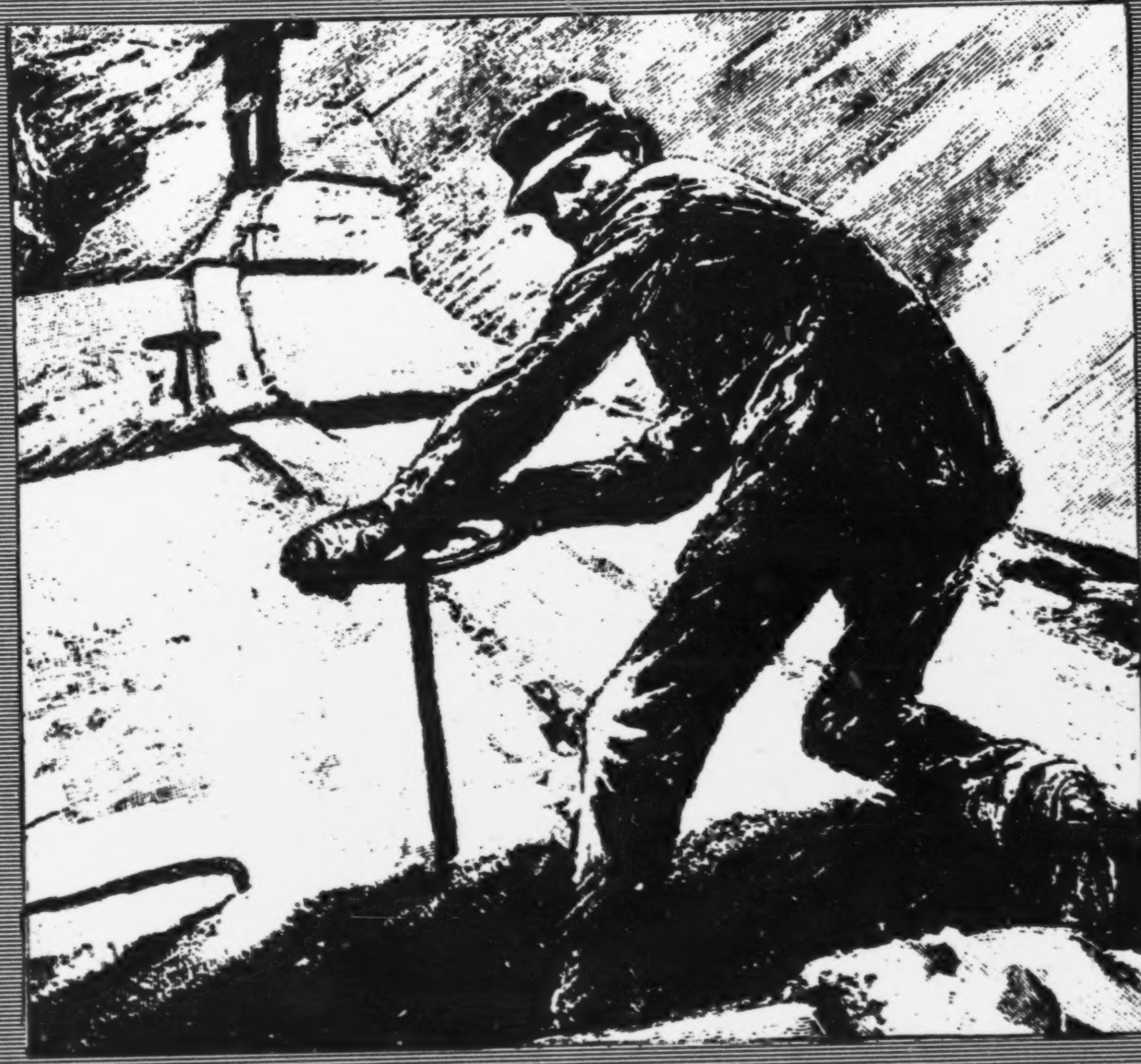

Systems Analysis and Synthesis Applied to Occupational Instruction in Secondary Schools

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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Systems Analysis and Synthesis Applied to Occupational Instruction in Secondary Schools

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Leonard C. Silvern
Project Director

A. INTRODUCTION

1. Identification of the Problem Area

The function of a school is the preparation of students for a particular behavioral activity which is expected to be implemented during a time period after the school function is terminated. Schools provide structured or formalized environments to communicate efficiently and are normally believed to be the most effective instruments for human learning and retention. Schools represent a practical solution to instruction by providing for the concentration of expert communicators in a physical facility designed specifically for human learning.

This project deals with one subset of schools: the secondary school. The secondary school is an institution which operates as a day or residential school providing education up to and including grade 12, such education being determined by State law (1). A common synonym for secondary school is high school and it is understood that a high school includes instruction up to and including grade 12 (2).

The function, then, of a secondary school is the preparation of students for those behavioral activities which are expected to be implemented after completion of grade 12, corresponding to 18 years of age, approximately.

The project as originally conceived was concerned with those secondary schools which were essentially vocational high schools or technical high schools. These schools are "specialized" or used "exclusively or principally" for occupational preparation (2). However, during the study it was noted that non-specialized secondary schools were introducing occupational courses into their traditional academic curriculums at an increasing rate. Such a school is termed "comprehensive" in that it has, "...as its broadest objective the teaching of all varieties of skill, all kinds of knowledge to all kinds of youth bent upon living socially profitable lives" (3).

The occupational phase in a comprehensive secondary school may differ in one or more characteristics from the occupational curriculum of a "specialized" high school. If there are any disparities insofar as this project is concerned, then the feasibility of developing a model, or the model itself, might reveal such differences. For this reason, the study was not rigorously limited to specialized secondary schools. It encompassed secondary schools where occupational curriculums were in use and where occupational teachers were at work.

2. Identification of the Problem

a. General. The function of a secondary school has been described generally as the preparation of students for real-life, at least that part which begins as the 12th grade ends. For those unfortunate individuals who do not reach the end of grade 12, then the secondary school also functions to provide preparation for real-life which may begin at any point in time between the 10th and 12th grades, ages 16-18 years, approximately. Also, the secondary school provides preparation for the "here-and-now" during the 10-12 grades, as well as preparation for post-graduation. In this project, concentration is placed on techniques which would be independent of these considerations.

The crux of the matter is that the secondary school must be as dynamic as the real-life situation in which it is embedded and of which it is a subsystem. A greatly simplified cybernetic model of a K-12 school, coupled through its output product [1.0] to several major real-life subsystems, is shown in Figure 1 (4).

Students [1.0] complete the 12th grade and enter one or more of these real-life situations:

Military service	[2.0]
Job	[3.0]
Degree-directed activities	[4.0]
Leisure Time activities	[5.0]
Continuing-education	[7.0]

Those unemployed or homemakers would constitute a subset of [3.0].

The dynamicism of this school is determined not by internal energy but by the inputting of energy from outside the school. Signal paths symbolizing this energy leave [2.0], [3.0], and [4.0], enter [8.0], leave [8.0] and enter [1.0] and [21.0]. This is an idealized model in which the signal paths constitute feedback energy. The system is closed and, under ideal conditions, should be in equilibrium. Changes in [2.0], [3.0], and [4.0] cause changes in [8.0]; this produces change directly in [1.0] and change indirectly in [1.0] through the path: [21.0]-[10.0]-[9.0]-[1.0]. A school must modify its curriculum as needs in real-life vary if the system is to achieve and maintain equilibrium.

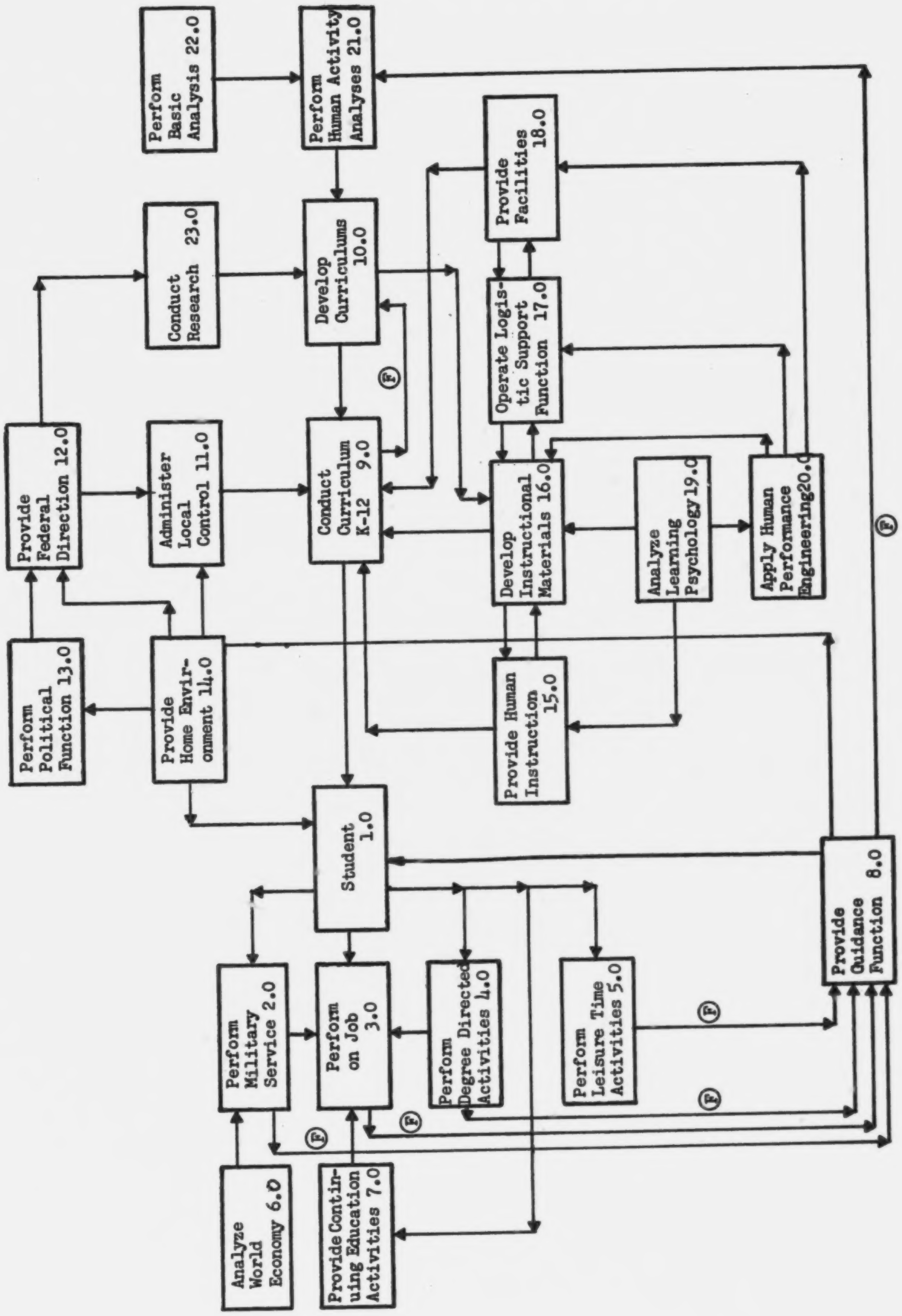
Student 1.0
Perform Military Service 2.0
Perform on Job 3.0
Perform Degree Directed Activities 4.0
Perform Leisure Time Activities 5.0
Analyze World Economy 6.0
Provide Continuing Education Activities 7.0
Provide Guidance Function 8.0
Conduct Curriculum K-12 9.0
Develop Curriculums 10.0
Administer Local Control 11.0
Provide Federal Direction 12.0
Perform Political Function 13.0
Provide Home Environment 14.0
Provide Human Instruction 15.0
Develop Instructional Materials 16.0
Operate Logistic Support Function 17.0
Provide Facilities 18.0
Analyze Learning Psychology 19.0
Apply Human Performance Engineering 20.0
Perform Human Activity Analyses 21.0
Perform Basic Analysis 22.0
Conduct Research 23.0
F
F
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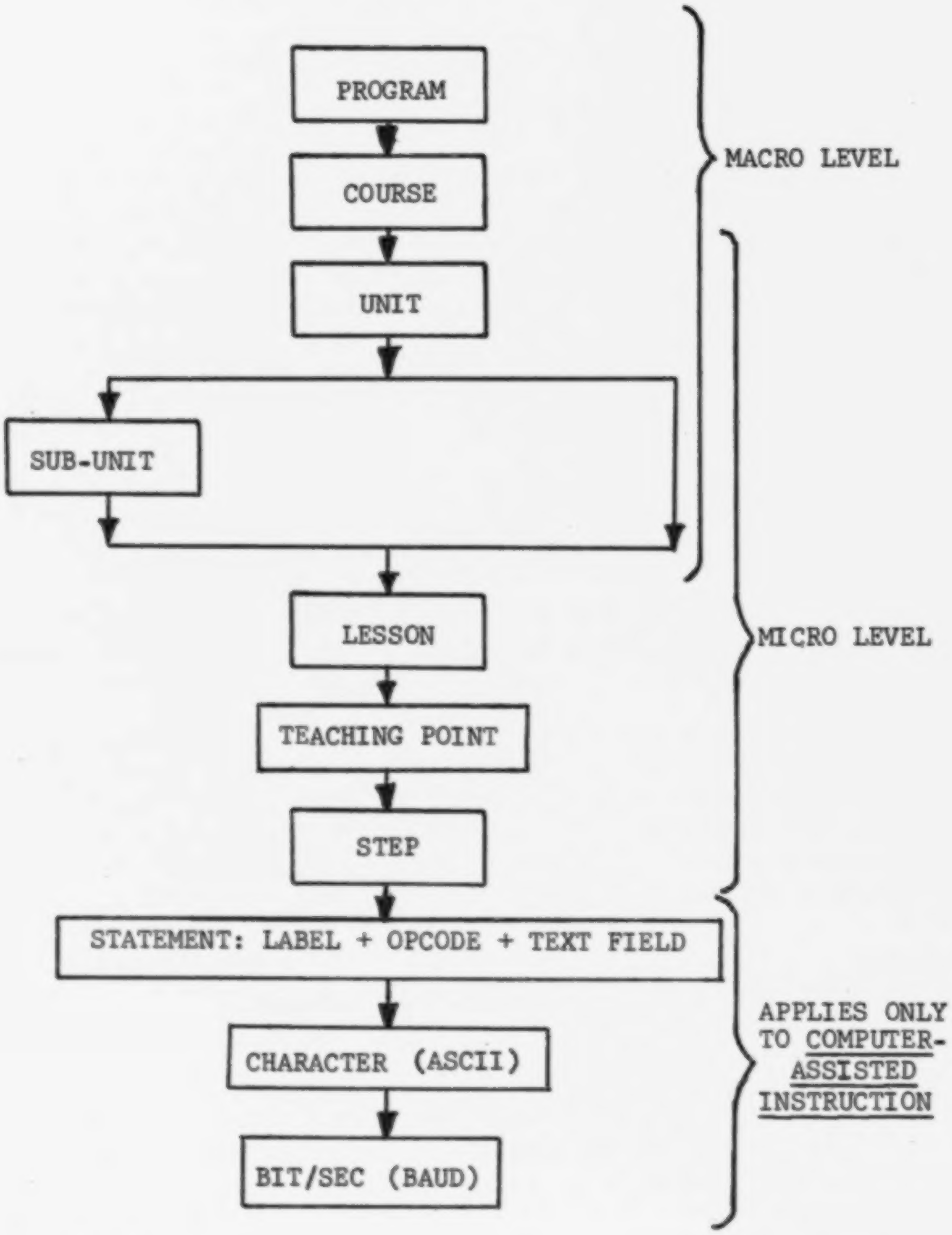
Figure 1

b. Feedback and Real-time. Assuming a secondary school has an occupational curriculum, then changes in a specific occupation [3.0] in the real-life situation should be anticipated by the school. Some occupations will tend to change more quickly than others, so the school will have to sensitize itself to those which are more dynamic. In terms of the model in Figure 1, the feedback signal path [3.0]-[8.0]-[21.0]-[10.0]-[9.0], or an equivalent signal path, should not only exist but it should operate in nearly "real-time." The concept of "real-time" for this system may be expressed as: "...a method of processing data so fast that there's virtually no passage of time between inquiry and result..." (5). In years past, this has been referred to by educators as a "time lag." Quite often, this concept is stated in such eloquent terms that the key message does not get across to the average reader even though it is critically important: "The national interest in education also requires that there be continuous testing of the ends and means of education, both to throw light on which are sound and effective and which are not, and to indicate new 'leads' on what to teach and how"(6). This narrative statement translated into systems terms would mean a closed-loop system with feedback signal paths such as those depicted in Figure 1.

If "real-time" means instantaneous action, then what is "nearly" real-time? Certainly it would not be a 40-year per cycle response time! This report will consider various feedback parameters as one aspect of the study.

c. Implications for Newly Instituted Occupational Curriculum. Another facet of the problem deals with a sudden decision by schools with college-preparatory curriculums to add occupational programs...to occupationalize part of its offerings...to become comprehensive in fact if not in name. Suddenness in the occupational field may produce instruction which is only as up-to-date as the experience of the instructors. Unless there is the built-in element of continuousness, of a closed loop system, this instructional experience will tend to age and grow old in the onrush of new methods, new materials and new procedures. Schools which have not offered occupational preparation are under increasing pressure to create and integrate such courses. This should be accomplished in a manner which would produce feedback continuously and not merely satisfy an immediate objective resulting from demands for a program.

d. Curriculum Change in Occupational Instruction. There are a number of methods, now traditional, by which occupational course content is changed. In most instances, the change consists of identifying obsolete content, removing it and substituting new material. These changes are of a moderately small magnitude, per course, ranging between the teaching point level and the lesson level in the hierarchy of levels shown in Figure 2 (7,8). Changes at these levels are micro adjustments.


PROGRAM
COURSE
UNIT
SUB-UNIT
LESSON
TEACHING POINT
STEP
STATEMENT: LABEL + OPCODE + TEXT FIELD
CHARACTER (ASCII)
BIT/SEC (BAUD)
MACRO LEVEL
MICRO LEVEL
APPLIES ONLY TO COMPUTER-ASSISTED INSTRUCTION

In an increasing number of cases, the magnitude of a change is great involving the course and even the program levels. Mere substitutions of new subject-matter for old is insufficient. Entire courses may be eliminated and completely new courses instituted. In some instances, a whole occupational field may be dropped from a school's offerings or a whole new program synthesized. Changes at these levels are macro modifications (9).

What motivates an occupational teacher to change a teaching point, a lesson or even a unit of instruction? What is the logical basis for his eliminating certain content and introducing new content? How does he become aware that a particular element of his instruction has become obsolescent? On what grounds does he conclude that a particular new method, process or material should be inserted into his lesson plan? What sources of occupational data does he use; how does he judge the reliability of these sources? Does he function at the macro or micro levels and to what extent?

A nearly identical set of questions might be asked when a school executive makes a decision to:

(1) eliminate an existing course or an entire group of courses
(2) introduce a new course or new program
(3) make no change in the occupational offerings

Assuming that no order to change the status quo has been handed down from a higher authority, what forces produce an administratively initiated curriculum modification?

This project explores the origins of course content and traces the flow of this information from a source to the student through the mediation of an occupational teacher. Teachers tend to make changes at micro levels while school executives operate at macro levels; this study is concerned with the teacher and changes instituted by him.

3. Objectives of the Project

This is a feasibility study and, as is common in such efforts, attempts to determine whether a theoretical concept has sufficient merit to be advanced to an operating stage. It is conceptual in that it is formulated from experience and is an extension of man's knowledge into a new and previously undeveloped field without actually conducting major experiments or field demonstrations. It may, however, require pilot exercises or some similar means of assuring that the theoretical model shows promise.

The study calls for synthesizing a model from the experience of the investigator and from the multiudinous experience and attitutes of those individuals listed in ACKNOWLEDGMENTS and their colleagues.

The objectives are to:

(a) identify elements which exist outside the secondary school subsystem from which information flows through a feedback signal path into the school subsystem

(b) select from the elements those which are believed to have a measurable influence upon the curriculum

(c) categorize, relate and combine or restructure these elements into meaningful relationships thereby creating a model

(d) analyze the restructured model

(e) evaluate the restructured model

(f) synthesize a new model based of the evaluation by combining previously unknown or unidentified elements and their feedback signal paths

(g) evaluate the new model to determine if it has merit and is worthy of further investigation

(h) publish the evaluation along with implications and recommendations

4. System Conceptualizations in Education, 1914-1964

Relationships between elements can be established and verified. When two or more elements are shown to have a relationship, they may be referred to as a system. A system is the structure or organization of a orderly whole, clearly showing the enterrelations of the parts to each other and to the whole itlelf. An instructional system is the structure or organization of an orderly whole, which deals with instruction, clearly showing the interrelations of the parts to each other and to the whole itself (4).

While many practitioners in education espouse the "systems approach" and "systems analysis" cause, a literature search reveals that there is little agreement regarding definitions, concepts and applications in actual school environments. The Project Director conducted an investigation into historical developments which led to what has become known as the "systems approach" to education (10). Prepared at the University of Southern California under U.S. Office of Education sponsorship, the final project report consists of two subparts: a view of education as a system; system in retrospect.

a. A View of Education as a System. In viewing education as a system, the fundamental concepts of system, analysis and synthesis are examined. The term systems approach is described as "the application of analysis and synthesis to a system. The iterative, high-speed mental process of analysis...synthesis...analysis... synthesis...analysis...synthesis...may be termed anasynthesis and this is, in fact, the real meaning of 'systems approach.'"

Bloom's definition of analysis (1956) is contrasted with the 1806 statement by Herbart and Silvern's further identification of analysis (1956) as a process consisting of four steps: identify, relate, separate, limit.

Bloom in 1956 described synthesis in virtually the same terms as did Herbart in 1806, while Silvern (1956) stated further that it was a process of four discrete steps: identify, relate, combine, limit.

Because of this remarkable coincidence which correlated qualitative viewpoints spanning a 150-year period, the project made a more detailed search of the literature of the early 1800's (10). Relationships in opinions expressed by Hegel and Leibnitz were revealed to have had a marked influence upon Herbart which, in turn, influenced Fechner. Herbart apparently was the first to develop a mathematical model of human performance...in 1816, he published a differential equation with its integrated form.

There follows an effort in the project report (10), to trace Herbart's "Formal Steps" which were complex abstractions through the contributions of his student, Ziller (1862-1874), in which clearness (Herbart) consisted of analysis and synthesis (Ziller). Rein, about 1885, further expanded analysis to include "presentation." In this manner, Herbart's 4 steps were expanded to 5.

DeGarmo and McMurry studied under Rein in Jena and imported these concepts into the United States (1889, 1892). Charters (1909) adopted the 5 steps and the Herbartian lesson plan, and in 1923, published the famous "Curriculum Construction" which deals with such modern day matters as analysis and job analysis. He acknowledges the contributions of Allen (1919) and Strong (1921) in this area and compares curriculum development with engineering development. But it was Allen and Allen alone who took the 5 steps, reduced them down again to 4: preparation, presentation, application, testing (inspection), and implemented them in the field of vocational education.

In evaluating Allen's contribution, the project report states that "...It translated the original thinking of Herbart, devoid of mysticism and shadowy concepts, and of DeGarmo and McMurry devoid of educationism into rational and immediately applicable techniques at the 'large system' level. Where Charters had failed to escalate upwards his conceptualization, Allen has succeeded..." (10).

In 1929, in "Efficiency in Education," Wright and Allen suggested that this analytic technique in vocational education be applied to general education (11). There was no measurable response to the appeal.

By 1942, it was meaningful to say, as did Keller: "The sharpest criticism of the traditional school has been directed against its lack of a sense of reality. Its cloistered teachers, without experience in the world of work, transmit to their pupils only what they themselves have learned from other teachers who had no contact with life, and so on as far back as you care to go. Essentially, this has been a just criticism...the vocational school never got into the circle because it was predicated upon life itself..." (10).

In an aside, the project report observes that the term "real-life" was used by Woods in the same issue of the National Society for the Study of Education Yearbook in which Keller's statement appeared. This term, real-life, is a recent adoption by systems engineering proponents and generally means: the structure and behavior of existing entities which may be objects, actions or information functioning separately or in combination. In education, it means all of those subsystems or systems outside a particular school or school district.

The project report refers to the teaming of effort by Allen and Cushman in the 1920's to apply these theoretical concepts to operating or real-life situations and the teaming of Allen and Richards in the 1910's to produce a mathematical model of learning efficiency. Reference is make of Cushman's contribution to the civilian employee training programs of the Navy and Army prior to and during World War II. Schaefer's application in 1941 of both job analysis and Allen's version of Herbart's formal steps to safety supervision is illustrative of the diversity of implementation. The "Training Within Industry" program of the

War Manpower Commission beginning 1940 again emphasizes the Allen-Cushman influence on those who initiated the effort: Gardner, Dooley, Dietz, Kane and Conover.

By the end of World War II, it was clear that analysis, job analysis and the "formal steps" had not only survived but were well embedded in vocational education and in business and industrial training. Silvern's linear flowcharting of "The Allen Plan" was published in 1943, 1946, and 1948 (10). The "formal steps" integrated into a lesson plan format appeared in an American Society for Engineering Education text by Morris (1950). A modified version appeared in 1952 in a New York State Education Department guide by Emerson. In 1961, Silvius and Bohn allocated an entire chapter, "Identify Content Through Instructional Analysis" to the methods of job analysis created by Allen, circa 1919.

Appearing in the closing paragraphs of that section of the project report is a summary:

> "...It has been established that there is a direct relationship with the present from the past in which analysis and synthesis were conceived by Herbart about 1800 and gradually evolved into job analysis and the four-step or "Formal Steps" method. From its inception, this movement dealt with the 'real-life' environment to which the learner must transfer what has been learned. It has been founded on a detailed analysis of real-life itself...it should be apparent that Charters, while deeply influenced by the Herbartians and Allen, was unable to make headway in general education as Allen had done in vocational education..." (10).

The following section of the project report describes developments subsequent to World War II and terminating in 1964. An effort is made to define the term "system," and upwards of 15 definitions by distinguished practitioners from many disciplines are presented. The design philosophy of the project report is stated thusly:

> "...To some, system connotes hardware or physical objects; to others, it infers or means software or non-physical concepts. This paper will attempt to steer a course directly to the fields of education and training within the set known as human performance. It will examine applications and views in physical systems as the base of experience. However, it will concentrate on non-physical systems within which one or more subsystems may be physical or 'hardware.' " (10)

Reference is made to models and simulation as groundwork for the detailed examination of system conceptualizations.

Such commonplace idiomatics as artist model and model prisoner are compared with training model, mathematical model, and flowchart model. Simulation is treated briefly to differentiate the process from the device: "simulator." The application of flowcharts is traced from radio circuit applications, circa 1915, to 1929 and beyond. The gross task "handling business orders" in a flowchart format published in 1914 is described and an early industrial engineering utilization of this concept is delineated. These lead to the beginnings of synthesis in the period 1926-1935 and the development of feedback amplifiers 1932-1945. Names such as Nyquist, Black, Bode, Brown and Hall in the field of electronics and automatic control stand out in the early days as do Wiener, Shannon, and Blackman during World War II.

The functional flowchart model as a qualitative representative is contrasted with several mathematical models which accurrately quantify the qualitative depiction. A 1952 functional flowchart model incorporating branching by G.M. Silvern in the field of cryptanalysis is discussed as an introduction to "The New Look."

Turning to the behavioral sciences, the project reviews the observations in 1951 of Wolfle:

> "...selection of what to teach obviously depends upon what the learners are to do with the skill or knowledge acquired... job analyses have frequently been made to obtain exact descriptions of the duties to be performed and the skills to be acquired...training is likely to get out of date unless constant effort is made to modify the training course to correspond with changes in the job...a different kind of job analysis, one that describes the task in terms of its psychological components instead in terms of its work units could frequently contribute..." (10).

Wolfle continues with a discussion of criteria for training success:

> "...two general types of criteria may be used--a criterion internal to the training or one external to it. An internal criterion is one that measures improvement or changes within the course itself. The examination in academic courses, the learning scores in most laboratory experiments...are internal criteria. An external criterion is one that is outside the course...success on the job is an external criterion of industrial training..." (10).

Silvern, in 1951, reduced Wolfle's belief to its lowest terms in saying "Remember---a fire cannot be extinguished with a training certificate..." (10). Later, in 1956, Silvern published

" Textbook in Methods of Instruction" which devoted nine pages to teaching machines or "pseudo-simulators" and established criteria which must:

> "...provide measurable and significant differences between actual job performance BEFORE using the device, and actual job performance AFTER using the device" (10).

Those who identified with psychology as a science, as differentiated from education and training, apparently were not aware of or devalued the analytical techniques described earlier. McGehee and Thayer (1961) and Glaser (1962) preferred to rely on psychological research and to discard all of the practical experience in vocational education. Travers (1962) was more lenient but equally tunnel-visioned when he said:

> "...Herbart himself was a philosopher...was in a much better position to influence educational thought than he was to influence educational practice... but his influence on educational practice is much more difficult to discern..." (10).

Up to this point, the project report has essentially established an historical frame of reference. In the succeeding section, "A Chronology of SYSTEM Conceptualization in Education and Training," the report examines conceptualizations characterized thusly:

a. nature of the model

(1) narrative	- concept is expressed in words
(2) graphic	- concept is expressed as Venn diagram, flowchart or other graphic analog
(3) mathematical	- concept is expressed using mathematical equations or statements

b. use of feedback to provide system stability (equilibrium)

c. use of simulation to

    (1) test model

    (2) process data through model

d. use of analysis to examine existing whole

e. use of synthesis to create new whole

These conceptualizations are identified and each briefly described below:

1. Swain - 1954

   A graphic model relating learner to instructor, identifying performance criteria as a subsystem, and specifying feedback as an essential ingredient.

2. Westley - MacLean - 1955

   A series of graphic models relating information transmitter to information receiver, specifying feedback as a crucial concept, and suggesting the subsystems may be a person, a group or a "social system."

3. Gerbner - 1956

   A series of graphic models, beginning with a general model patterned from the Shannon model, is based upon a "closed sequence" using feedback as in an automatic control system. From these, mass communication models revealing feedback, misperception, and communication failures could be built.

4. Silvern - 1956

   A graphic model relating a classroom unit of instruction with a laboratory unit of instruction and the latter with integrated work experience on a job in real-life. Feedback is shown from laboratory to classroom instruction, from work experience to laboratory instruction, and from work experience to classroom instruction. In this manner "the curriculum will be continuously modified to meet occupational needs."

   A series of mathematical models growing out of the Richards equation of 1919 and the Keller version of 1943 were also presented. It equated the efficiency of the training program graduate with four kinds of course content coupled with the learner's attitude.

   These models were extended by G.M. Silvern in 1961 by including a time parameter.

In 1960, a graphic flowchart model relating the learner, teaching machine, and work (both mental and/or manipulative) was published. Feedback from machine to learner was specified.

In 1961 a graphic flowchart model illustrating the sequence and synthesis of training was published. It related the functions of job analysis, course outline, lesson plans, teaching machine lesson plans and job performance standards. Feedback is specified.

5. Mitzel - 1957

A graphic flowchart model relating pupil variables, pupil behaviors, teacher behaviors, pupil-teacher interaction, changes in pupil behavior, teacher variables and environmental variables appeared. Feedback was specified from pupil variables to environmental variables and from changes in pupil behavior to pupil variables. It was used to assist in precisely localizing area which warranted research activity.

6. Rothkopf - 1957

A graphic flowchart model related the students with a machine consisting of 8 subsystems. These subsystems were not physical components but represented the functions performed. A signal path from Response Evaluation Indicator to Student was essentially feedback.

7. Martin - Russell - 1958

A graphic flowchart model related student, education process (university), faculty, industry, external evaluation in industry, internal evaluation in education process, experiences of other colleges, and comparison/decision functions. It was narratively described as a closed-loop system with an error-sensing mechanism and a feedback control/loop. Also mentioned were "many internal feedback loops... couplings between professors, courses, prerequisites... detection of error signals and the effect produced by the feedback process is normally very slow... system interest, which is an intrinsic characteristic of engineering, has been neglected..." (10). The authors concluded, "...the entire question of systems concepts is the next major error signal in the educational servosystem. Can we overcome the slow response of the feedback loop?..."

8. Porter - 1958

A graphic flowchart model relates the student with hardware + software elements of a machine for language learning. Feedback to the student from the machine software is inferred but not specified; this was an audio message output into earphones.

9. Runkel - 1958

A series of graphic flowchart models were produced which related teacher's personal history, teacher's choice of goal using pupil, teacher's frames of reference, teacher's act, environment, pupil's personal history, pupil's goals, pupil's frames of reference, pupil's act, environment (pupil). One model delineated the teacher's act and the pupil's act relationship in which two filters were inserted: the teacher's frame-of-reference filter and the pupil's frame-of-reference filter. Feedback is not specified but may exist inferentially.

10. Weimer - 1958

A series of graphic flowchart models appeared which related a number of students to a machine subsystem consisting of instructional software (lesson plans), recording and control software, and hardware with the objective being learning. The control hardware might be a digital computer. Feedback is specified between learner and machine through one or more kinds of presentation equipment.

11. National Academy of Sciences - 1959

A narrative model which was sufficiently descriptive to allow for reader construction of a graphic flowchart model appeared in a publication by a task force engaged in "apparatus of teaching." Regrettably, as in nearly all narrative models, the key words are imbedded in large numbers of noise words and only the experienced reader can construct an accurate analog. Feedback is mentioned but not specified.

12. Folley - 1959

A graphic flowchart model related stored information, stimulus, response selection, response, criterion, comparison, and feedback from comparison to response selection. This was termed a behavior paradigm.

13. Tucker - 1959

A graphic flowchart model illustrated hardware-software relationships in the Atlas Missile System.. The narrative accompanying the flowchart emphasized "task analysis" as the key to successful functioning of the system. The values in this presentation are in the narrative model which is a prescription for performing job analysis.

Melton, in summarizing, said: "...when the goals of education are expressed in terms of the human functions and tasks to be performed in a social system, I suspect that they can be as exactly and objectively specified as can the human functions and tasks in the Atlas Weapon System. If this is so, then the same technical logic will apply to education media and training media..."

14. McPherson - 1960

A paper entitled "Let's Look at the Systems Concept of Educational Planning." However, the "ecology" in the paper is the environment of the school and not the environment of the non-school. There was no model of any kind, simply a rearrangement of well-worn words and phrases with a liberal sprinkling of a few systems engineering terms.

15. Riley and Riley - 1960

A graphic flowchart model described the interrelationships between teacher and student. The teacher is influenced within the school by formal school groups and primary groups; from the community by formal educational groups and primary groups; from outside the community by the teaching profession. The student is influenced within the school by formal school groups and peer groups; from the community by family and peer groups. The community is influenced from outside by mass media. Feedback is not shown in the flowchart model but the accompanying narrative infers feedback: "...any slight disturbance introduced into the system will have ramifications throughout the whole, and will be counteracted by various reactions tending to restore the state of equilibrium..."

16. Pask - 1960

A series of graphic flowchart models related the student, a teaching machine, and instructional software. Feedback from scoring device to teaching machine permitted it to learn. Thus the teaching machine had the capability to learn and to re-program itself or shape its behavior as a result of the student's behavior. In addition, an abstraction in the form of a mathematical model was produced.

17. Galanter - 1960

A series of graphic flowchart models related several subsystems within a single learner, and showed inputs and outputs. These were apparently the first such models of the learner as a subsystem.

18. Shettel - Lumsdaine - 1961

A graphic flowchart model related learner variables, programming variables, training needs and objectives, and presentation methods. Feedback was not specified.

19. Buddenhagen - Wolpin - 1961

A graphic flowchart model related trainee, 6 stimuli displays, 5 stimuli generators, controller, and computer which was used for visual simulation in astronautical flight training. Inputs from trainee to computer caused stimuli generation and display-type feedback to the trainee.

20. Demaree - 1961

A three-dimensional graphic figure was used to describe interrelationships in TEPI, the Training Equipment Planning Information document used in the U.S. Air Force. It was substandard in communicating sequential relationships but was accompanied by several graphic flowcharts which were superior. Feedback is not specified but may be inferred from the models.

21. Stolurow - 1961

A graphic flowchart model of learner, machine, and program appeared in a chapter entitled, "A Systems Approach to Instruction." Another flowchart model depicted learner-machine-program relationships at a lower level of detail. Entitled "adaptive teaching machine system" it represents software capable of adapting by learning and storing under programmed control.

In 1964, Stolurow published "A Taxonomy of Learning Task Characteristics" and a graphic flowchart model relating trainee, trainee input, trainee output, task, feedback, and performance standards.

22. Silvius - Bohn - 1961

Two graphic flowchart models appeared in a textbook on "Organizing Course Materials for Industrial Education." One attempted to illustrate paths followed by a typical student from elementary school to university. The other attempted to graphically describe relationships between philosophy of education, school philosophy, general school aims, general department aims, and specific course aims. Both failed to communicate what was intended and the caption which stated in part "...this is an effective technique for showing the relationships between..." was misleading. These were in occupational education.

23. Air Force Dynamic Forecasting - 1961

To introduce these models, it was necessary first to review the earlier work of Forrester in the field of industrial dynamics. In 1957, a graphic flowchart model which he published related factory, factory warehouse, distributors, retailers, and consumers. Feedback was specified and Forrester accompanied these models with mathematical models. In 1964, he stated that "...management, economics, and much of engineering share common foundations in feedback system behavior and psychology...what does technical engineering bring to enterprise engineering? Five contributions seem conspicuous:

1. the concept of designing a system
2. the principles of feedback control
3. the clear distinction between policy making and decision making
4. the low cost of electronic communication and logic
5. the substitution of simulation for analytic solutions

The Air Force graphic flowchart model consists of a qualitative flowchart and a separate quantitative overlay which describes each function in the form of a mathematical equation. This is the Forrester technique of modeling. It represents the "knowledge-progress" system and involves many functions including students, teachers, employment, labor force, facilities, research, etc. Feedback is inherent in the design.

24. Heinich - 1962

Two graphic flowchart models were produced. In one, relations of a sequential nature were shown, dealing with curriculum determination, curriculum planning, classroom application, and the traditional audio-visual function. In the other, instructional technology replaces the traditional audio-visual function and the injection points and inputs occur much earlier in time. There are no specifications for feedback.

25. Travers - 1962

A graphic flowchart model dealt with education as a system to be changed, identified conditions blocking or facilitating change and scientific activities tending to produce change. Feedback is specified but the narrative states the system "...includes a feedback component which is usually ill-developed and informal."

26. Hall - 1962

A series of graphic flowchart models were published. One illustrated John Dewey's problem-solving technique and related indeterminate situation, problem situation, getting ideas, idea evaluation, and problem solution.

The second model was a generalization of the decision-making process relating problem situation, problem definition, decision making, systems synthesis and analysis, planning for action, and action.

The third model was an effort to bridge a gap: "...idea getting in Dewey's model and systems synthesis in the new model mean virtually the same thing..." It described analysis-synthesis as a generalized problem-solving technique. Feedback is specified in all models including the Dewey flowchart.

27. Maccia - Maccia - Jewett - 1962

A paper was published by E.S. Maccia, "The Conceptions of Model in Educational Theorizing," which analyzed statements, equations and diagrams which were termed "models." The literature search produced 37 documents. Nearly all were from educational journals with a few from semantics or linguistics. Only one model corresponded with those just described; Gerbner - 1956. The paper concluded "...the prevailing conception of model has nothing to do with the process constituting or related to educational theorizing..."

A paper by G.S. Maccia appeared in 1962, "An Educational Theory Model: Graph Theory," which presented a series of graphic flowchart models which were in the subset of flowcharts known as "digraph" or "directed graph" (12) or simply "graph" (13). An effort was made to apply graph theory to characterize the relations of persons in groups within a school. Then, a typical flowchart model was produced which related teaching unit, facilitating unit, inquiring unit, and administrating unit as subsystems within a school subsystem. Outside of the school subsystem is an environment including physical, biological, psychological and social context. Feedback is specified and the narrative states: "...without feedback of school output, the property of independence will increase until the school degenerates..."

A paper by Jewett, "An Educational Theory Model: Agricultural Economic Theory," continued the application of some of these concepts by producing a narrative model relating agriculture to the elementary school.

28. DAVI Task Force - 1963

A graphic flowchart model depicted relations between pupil, system, content and method decisions, and objectives. Feedback is specified but it is combined with an evaluation function. "System" was defined in the model as: teacher alone, teacher with media, media alone.

29. Silvern - Higher Education/Medicine and Dentistry Model - 1963

A graphic flowchart model was presented which related a large number of functions in a university setting for the professional education of physicians and dentists.

The model is closed-loop with inputs from real-life to various curriculum functions. Feedback is inherent in the design.

30. Silvern - Training System Model - 1963

A graphic flowchart model was developed for business and industrial applications. This related trainee, job, customer, selection method, course, human instruction, lesson planner, job analysis, basic analysis, learning psychology, machine instruction, and logistics. Also an error filter and a distortion filter were shown. Many of these functions were further broken down into subsystems as much as to the fourth level of detail. It was narratively described as a step towards the preparation of "...a general system model which could be tested..." Feedback is inherent in the design.

31. Rath - 1963

A graph flowchart model was produced to develop some rules of synthesis. It was accompanied by a mathematical model. Feedback is not specified.

32. Educational Media Council - 1963

A paper, "A Proposal for Long-Range Educational Analysis and Planning, " was produced by the Systems Analysis Committee of the Council. There were no narrative, flowchart or mathematical models but it did contain a well-grounded justification for such a study.

33. Ofiesh - 1963

A graphic flowchart model illustrated U.S. Air Force, Air Training Command, curriculum development relationships. Feedback may be implied from the model.

34. Lumsdaine - 1964

A series of graphic flowchart models were published. In one, the model was to show "...interrelationships among the developments in physical and beharioral sciences related to educational technology." Feedback was not specified.

In the second, the purpose was to show "...converging streams of influence affecting present concepts and practices in programmed instruction..." Feedback was specified.

35. Griffiths - 1964

A series of graphic flowchart models appeared in a chapter of "The Nature and Meaning of Theory." One in particular illustrated functional relationships within the administration subsystem. Feedback was inherent in the design

36. Egbert - Cogswell - 1964

A series of graphic flowchart models were published in a document on "System Design for a Continuous Progress School." These flowcharts are in the subset known as "computer programming flowchart." Feedback was inherent in the design.

37. Syracuse University Conference - 1964

A number of papers were presented at a conference of "New Dimensions for Research in Educational Media Implied by the 'Systems' Approach to Instruction." Three of these were selected for detailed study. Of the three, only one presented a model---of the narrative type. All three emphasized the need for mathematical models but none were presented. The authors were Churchman, Mood and Stolurow. A summarizing statement by Vandermeer said: "...models of school systems could be constructed within the parameters defined by various objectives to be included and excluded from the public school domain. No aspect of such models would be more important than instructional media which, in themselves, would need to be described with far greater precision than they have been up to now...."

38. Air Training Command System Planning Workshop - 1964

A graphic flowchart model was produced during a 5-day conference along with a number of brief, functional descriptions. The model at the first level of detail consisted of 7 subsystems: feasibility, design planning, strategy, production, field test, implementation, and maintenance. It was "A Model For Designing Instructional Systems." The workshop discussant-consultants were Bouck, Corrigan, Deterline, Kaufman and Silvern and the evaluator-consultants were Bern and Mayer. The flowchart model was conceptualized by Silvern to the fourth level of detail based on a narrative model provided during the workshop by those participating. Feedback was inherent in the design.

39. Eckstrand - 1964

A graphic flowchart model was developed which related: define training objectives, develop criterion measures, derive training content, design methods & training materials, training program, trainees, graduates. Feedback was specified.

40. Abma - 1964

A graphic flowchart model was produced which related: educator or manager sets training goals, designer of instructional materials, early stages of development, criterion, instructional materials, and students. Feedback was inherent in the design.

41. Silvern - Public Education K-12 Model - 1964

A graphic flowchart model was published which related: student, higher education, military service, job, continuing education, parents, county-state-federal standards, local administration, curriculum K-12, curriculum planning, occupational analysis, basic analysis, guidance, learning psychology, machine instruction, logistics, media, human instruction, and facilities. Feedback was inherent in the design. The narrative stated: "...By tracing the signal paths relating the 19 subsystems, one can quickly see that this particular model is mainly concerned with curriculums and the transfer of what is learned to real-life situations...hopefully, we will see the day when a detailed flowchart of the general system will be available. The logical next step would be to develop an overlay of a mathematical model for it..."

42. Rath - Schroeder - 1964

A series of graphic flowchart models were published in a paper by Rath, "The Analysis of Behavior for Education and Training." One model, entitled "A Systems Approach to Programming P.I. Materials" had feedback inherent in the design. A second, entitled, "Task and Behavioral Analysis of Behavior," was devoid of feedback.

In a student study project, separate from the other paper but under Rath's direction, a graphic flowchart model was published which illustrated the sequence of events in conducting the project. A second model combined a graphic flowchart with mathematical equations and depicted the "educational establishment."

A paper by Schroeder and Rath, "The Role of Mathematical Models in Educational Research," appeared and, while no models were demonstrated, a number of avenues were explored.

43. Barson - Jones - 1964

A graphic model commonly known as a Venn diagram (5, 12) related: administrator, instructor, design coordinator, behavioral analyst, evaluation specialist, technical supervisor, instructional specialist, media specialist, audio-visual specialist, and materials librarian. Later, a graphic flowchart model was developed as a step towards the formal conception of the instructional system.

44. Boeing - ETC - BSD - 1964

A graphic flowchart model, "Model for Designing a Boeing Instructional System," was produced by Silvern during a "Special Systems Analysis/Synthesis Training Program" at The Boeing Company. For the MINUTEMAN Missile System, the project was supported by Ballistic Systems Division, Air Force Systems Command. There were a large number of subsystems and feedback inherent in the design.

45. Autonetics - ETC - BSD - 1964

A graphic flowchart model, "Instructional System Model," was produced by a team of specialists including Silvern and Skaggs at the Autonetics Division, North American Aviation, Inc. As in the Boeing model, this was for the MINUTEMAN Missile System and was supported by BSD. A large number of subsystems with feedback signal paths appear in the model.

46. University of Pittsburgh - 1964

The U.S. Office of Education established the Learning Research and Development Center at Pittsburgh and, among its objectives was this: "...provision and ready availability of prototype models of instructional systems, including both material and procedural components for particular purposes..." No models were described in the announcements.

b. System in Retrospect. The original version in (10), constituting the second subpart, was entitled, "System in Retrospect," and it followed the earlier subpart, "A View of Education as a System."

Because of the limited distribution of the document (10), "System in Retrospect" was expanded and retitled "Systems Analysis and Synthesis in Training and Education," appearing in 1965 (4). In the following review, both versions (10, 4) will be referred to.

This section reviews the 46 contributions between 1954 and 1964 stating: "An emphasis was placed upon the flowchart model rather than the narrative analog because subsequent monographs in this series will rely on graphic and mathematical models...little was reported on the mathematical model since very few studies were found in education and training which reflected thought in this discipline" (10).

The project report continues: "...The evolution of the flowchart model suggests that only recently has the servotheory concept of 'feedback' and the use of the flowchart as a 'model' developed. Many flowcharts were intended to be 'descriptions' rather than 'models' to be tested or validated with real-life criteria. Very few of these analogs were aforethoughts or synthesis; most were afterthoughts or graphic descriptions of the system. Consequently as 'descriptions' and not 'models' there was no requirement to test and modify them against some criteria..." (10).

The project report examines the concept of system and illustrates how the process and analysis and synthesis are utilized. Attention is given to simulation, evaluation, debugging, fabrication, maintenance, and elimination. In a figure entitled, "The Flowchart Model Describing the Process of Developing a System," all of these functions are functionally related and two feedback loops are shown.

Synthesis is described as a process and is defined as: "combining non-related elements, showing the relationship of these elements to each other, until there is a new whole." It is differentiated from assembly in that the parts or elements in assembly are known and the order or plan of assembly is known. The steps in synthesis are identified as: "identify...relate...combine... limit." (4).

Synergism is defined, from physiology, as the cooperative action of discrete agencies such that the total effect is greater that the sum of the two effects taken independently, and more generally as "...the whole is greater than the sum of its parts..." (10).

In a discussion of "systems approach," the term anasynthesis is introduced:

> "We have defined ANASYNTHESIS as the application of the process of ANALYSIS and SYNTHESIS to the development of a SYSTEM. It is characterized as basically a mental process, performed very rapidly and iteratively as analysis... synthesis...analysis...synthesis...analysis, etc. However, it may also be performed in a large SYSTEM...Not only is ANASYNTHESIS being performed in the first subsystem, but it is, in fact, being performed as a process throughout the total sequence of events. Thus, through the effect of SYNERGISM, we see an outcome which is more logical, more organized, more structured, more cosmotic and more responsive to real life requirements. This effect of SYNERGISM which produces ANASYNTHESIS is what the writer believes is meant by the more popular term, SYSTEMS APPROACH. However, there are some characteristics of the SYSTEMS APPROACH which require modeling and simulation which are not inherent in the classical definitions of ANALYSIS and SYNTHESIS (10).

Various classes of models are examined and these statements are made to clarify the issue:

> "Not all of these new models are mathematical notations. One subclass of these is the flowchart model. It can be qualitative or quantitative or both, depending upon the objectives of the problem. While the flowchart model is also symbolic, that is the elements of it are not in words or phrases but in a special language which must be learned to be understood, it is a graphic analog. In this sense, it can be understood by many persons who are troubled by purely mathematical models and by the tremendous variety of mathematical techniques which must be understood first if the model is to be comprehended. The writer feels strongly that the flowchart model or graphic analog is better understood by the average, professional in the field of education and training than would be the mathematical model. If the purpose is to communicate a conceptual feeling for modeling, this is more expeditiously accomplished with flowcharts" (4).

The utility of the mathematical model or expression is evaluated thusly:

> "The expression is a low-fidelty model of real life in the sense that it physically does not look like the real life SYSTEM. However, if the answers or solutions are accurate

in terms of real life problems, then it may have a high-fidelity evaluation..A number of modeling techniques are being developed and these primarily deal with some form of mathematical notation. The effort to quantify in areas of social science where previous qualitative methods have been employed is increasing" (4).

On Modeling an Instructional System:

"One of the first questions to be answered is: is the model designed to be symbolic of an object....of an action.....of information? In most instances, in dealing with an INSTRUCTIONAL SYSTEM, we will find that our model will be a combination of action and information. That is, the functions in the subsytem blocks or rectangles will describe a human *action* or human *information* processing.

"Another question to be answered is: should the model represent real life as it is and then a modified version of this model made to represent real life as it should be.... or....should the model represent real life as it should be? You should not have the impression that all models must be extremely high fidelity representations of real life *as it is*! Those of us who intend to change and improve mankind will certainly want to produce models which introduce new ideas. One way of satisfying this objective is to develop a model of real life as it is and then gradually vary elements in the SYSTEM to see if there are optimum conditions which would result in better outcomes. One could go immediately to a theoretical model and then determine whether this could be accomplished in real life by instant change or by evolution.

Regardless of the design objectives, the model will be the result of the process of ANASYNTHESIS" (4).

On Feedback:

"The writer hesitates to state that *all* INSTRUCTIONAL SYSTEMS must have feedback. Certainly, the concept of feedback which is used to stabilise a system will produce more logical outcomes...this concept would be extremely useful in an INSTRUCTIONAL SYSTEM to provide some organized means of quality control...we find that *major* feedback signals from the real life environment *which is outside the physical school or company training program* and are inputted into the school or training program so as to produce an error signal and thereby cause change in the curriculum function. Thus, the concept of INSTRUCTIONAL SYSTEM, as viewed in these models, has the school or training program as a *subsystem* of the total system and not the total system itself. This decision which results from ANALYSIS, the identifying of the real life environment and the relating of it to the learner and to the other functions, is fundamentally the designer's decision. As a result of this decision, he may SYNTHESIZE a model which does or does not have subsystems outside the physical school...If the school and the training program were created to produce learners who, upon graduation, are able to be matched to the functions in the world outside of the school or program, then the designer has no choice...he must SYNTHESIZE elements from the outside.

Once a model has been created, it must somehow be tested or checked out to see if it does represent the design objectives" (4).

On Simulation as a Process:

"...We are not talking here about training devices used as models, but about graphic analogs such as the flowchart used as a model. When we employ the term "simulation", we do not mean "simulator" or training device...do not mean hardware device...do not mean the use of a digital computer...having listed most of the things which we do not mean, we are ready to find out what we do mean when we use the term simulation...The technique of testing the model is called SIMULATION. The model which has been SYNTHESIZED now exists. However, aside from personal opinion, there is no reason to believe that, as a conceptualization, it works. There is no reason to believe, if real life is one of the parameters, that it does reflect real *life...that it is a high fidelity model. If you take* this model and process some data through it to see if it does produce some predictable results, then what you are doing is SIMULATION. If there are any errors or malfunctions, these are evaluated and debugged...the second SIMULATION is conducted and evaluation and debugging again occur. This process of refinement of the model continues until there is a belief that one additional SIMULATION will not produce sufficient bugs to make it worthwhile. At this point, the final model is ready to be fabricated..." (4).

On Processing Data Through the Model:

"...a designer may have conceptualized the model so it can be used day after day to try out his ideas on it...it does represent real life on a symbolic basis...he will want to try out each new proposal he receives to see if it has any usefulness. He does not have to guess or to go to the expense of actually using the new proposal...he can simulate using the new proposal on his model.

Having validated his model, he can now process the proposals and see what the outcomes are. This is called processing data through the model. It is also SIMULATION but it differs from the SIMULATION used earlier to test the model. This SIMULATION is to process data.

From time to time, the designer will have to update his model if conditions in the real life environment change. Also, his curiosity will be aroused and he will want to change some of the elements of the model just to see what should happen if he inserted some feedback where it did not exist..." (4).

On Complexity Level:

"...COMPLEXITY LEVEL may be defined as the scope of the SYSTEM as prescribed by a boundary drawn around the SYSTEM within which is found the SYSTEM being studied; the number of elements within the SYSTEM, consisting of functions and interrelations characterized by signal paths, will determine the COMPLEXITY LEVEL. Very large SYSTEMS have a large number of such elements, very small SYSTEMS have a small number of such elements..." (4).

On the Identity of an Instructional System:

"...Once a SYSTEM has been identified by drawing a boundary around it within which everything is a part or element of the SYSTEM, these elements may be analyzed since they exist... this requires the process of identify, relate, separate, and limit. If the SYSTEM being analyzed consists of objects, actions, and information, then the techniques of ANALYSIS are applied to objects, actions, and information. Probably in education and training, the actions and information analysis will lead...a SYSTEM is whatever the person identifying it says that it is. The writer hopes that INSTRUCTIONAL SYSTEMS include within them part of the real life environment for which the learners are being prepared and from which feedback may be obtained to cause the curriculum parts of the SYSTEM to be modified to keep up with, or even ahead of, the needs of the real life environment..." (10).

"...A SYSTEM may be analyzed into its parts. The major parts of a SYSTEM, also known as the major functions, are called SUBSYSTEMS. A SYSTEM must have two or more SUBSYSTEMS.

If it has only one SUBSYSTEM, then that SUBSYSTEM is not a SUBSYSTEM but it is the SYSTEM itself.

The SYSTEM, then, consists of the total number of SUBSYSTEMS and the total number of interrelationships shown by signal paths relating them to each other..." (10).

On Supersystem and Suprasystem:

"...The SUPERSYSTEM is a whole in which the major functions at the first level are SYSTEMS. Normally, the SUPERSYSTEM is conceptualized during the process of SYNTHESIS rather than ANALYSIS. It results from an awareness and a discovery that the SYSTEM being studied has some relationship with one or more other SYSTEMS and that this was unknown. Identifying the other SYSTEM or SYSTEMS, relating them and combining them into a new whole, called a SUPERSYSTEM, is the process of SYNTHESIS..."

"...The SUPRASYSTEM is a whole in which the major functions at the first level are SUPERSYSTEMS. As in the case of the SUPERSYSTEM, normally it is the process of SYNTHESIS which produces the SUPRASYSTEM...The SUPRASYSTEM in formal education and training in the United States has not yet been conceptualized as far as is known..." (10).

On Functional Objectives:

"...In conceptualizing a SYSTEM, not only is the COMPLEXITY LEVEL signigicant, but the designer's purpose in developing the SYSTEM is similarly important. Most SYSTEMS are directed towards the learning objective...the STUDENT is the most important SUBSYSTEM and every other SUBSYSTEM in the school is directed towards learning. However, what is learned and how well it must be learned should be dictated by the real life environment for which the student is being prepared... the learning situation must be stabilized by feedback signals returning from the real life environment for which the student is being prepared. The STUDENT remains the most important SUBSYSTEM. This not only reflects the dignity of man in society, but also reflects the doctrine of democracy and the inherent worth of the human being...Whether cost is one of functional objectives of the Public Education SYSTEM or whether it is the prime functional objective is in the realm of 'designer's choice.' This means that the designer of the Public Education K-12 SYSTEM must establish in his mind whether cost is the most important consideration, whether the teacher...the human instructor...is most important, whether the learner is most important, whether the administration is most important, whether the legislature is most important, etc. Obviously, only one is most important..." (4, 10).

On Functional Operating Levels:

"...In conceptualizing a SYSTEM, the COMPLEXITY LEVEL, by definition, will prescribe a boundary within which is found the SYSTEM being studied...it may encompass interrelated elements which operate at the national level in the United States...such an INSTRUCTIONAL SYSTEM may incorporate all the Federal agencies involved with education, all of the state agencies, all of the county, city, town and village, and unincorporated areas, all of the schools, all of the staffs, and all of the students.

"Another conceptualization of an INSTRUCTIONAL SYSTEM may encompass only those elements found within a specific state. A third and different conceptualization could be at the school district operating level and encompass all of those elements operating within the administrative boundaries of that district as established by law and all of the elements in the real life environment, including relations with other governmental agencies, the world of work, the world of play, etc.

"One could conceptualize the operating level as being the classroom. In this model, we would see that the major SUBSYSTEMS are the student, the teacher, and the curriculum... In the absence of the human teacher, and the presence of programmed instructional materials and teaching machines, we should see a different model. Finally, if the operating level being modeled is at the learner level, then the STUDENT is the SYSTEM and one must conceptualize the SUBSYSTEMS within the STUDENT, describing the inputs, outputs, feedback, functions, etc. That this is not only possible but that it is probably an essential step in the development of all SYSTEMS of this type, has been demonstrated by several individuals..." (10).

The project concludes with 111 bibliographical references.

5. Systems Analysis and Synthesis in Education, 1965-1967

In connection with this feasibility study, a further analysis of the technical literature was conducted for the period 1965-1967. The literature search was categorized into two areas: systems techniques in education and training; systems theory and techniques in other disciplines. Narrative models were bypassed while emphasis in the search was placed upon graphic flowchart and mathematical models.

a. A Word About the Narrative Model, Feedback and Systems Approach. A large number of technical papers and chapters in books on education and training refer to a "model" or "paradigm." In nearly all instances, the models are word conceptualizations and not graphic flowchart or mathematical models. For example, Scheffler (1965) examines three"philosophical models" of teaching which "...do not so much aim to describe teaching as to orient it, by weaving a coherent picture out of epistemological, psychological, and normative elements..." (14). All three models are narrative models and suffer from a wide variety of interpretations by those who examine them.

The term "feedback" as used in systems engineering is not similarly defined or well understood by those in education who use it. Forrester (1964) has stated that "the principles of feedback control" are one of five contributions by technical engineering. He believed that "...management, economics and much of engineering share common foundations in feedback system behavior and psychology... (10).

Goldberg (1964) in discussing principles of automatic control, states: "...Automatic control is a process of a dynamic system in which a particular function is directed consistently according to some specific plan or casual factor...in order to accomplish a given task effectively, and therefore be self-regulatory, control must be provided with feedback paths to correct deviations from the desired behavior. Systems with such functions are said to be closed-loop. An open-loop control system is one without and provision for control modification resulting from recognition of the system output..." (15).

Wilson and Wilson (1965) describe feedback:

"In any feedback system

1. a wanted output performance reference is supplied;

2. some function of the controlled variable is examined to see how closely the output performance agrees with the reference;

3. the difference between the wanted and actual performance generates an error signal;

4. power is applied under the control of the error signal to reduce the difference so that it approaches zero"(16).

Engineers understand that feedback *changes the behavior* of the function receiving the feedback and that this is consistent and not sporadic.

Markle (1967) in discussing programmed instruction states:

> "Feedback to the instructor from the student is, of course, not new in education. Even when lecturing to large groups, lecturers may ask for questions from the floor, leading to restatements, further examples, and so forth. This experience may lead to a revision of the lecture for future presentations..." (17a).

An engineer might observe that feedback *must* change the behavior of the function; if it *may* or *may not*, then the system is open-loop or is malfunctioning.

Lange (1967) presents a "generalized flow chart of program development" which has feedback signal paths to earlier functions. However, the accompanying text describes feedback to *different* functions than does the model. He equates "feedback" with "recycling." (17b).

Air Force Systems Command defines "feedback system" as:

> "A system in which the difference between actual performance and desired performance is used as a basis for modifying inputs to the system so as to achieve or maintain the desired output..." (18).

Marx and Hillix define feedback as: "In an energy system, the part of the output energy that is returned to the system to regulate further output." (19)

If the behavioral scientist wishes to borrow terminology from the physical scientist, and to use physical systems for modeling social systems, then the terminology should be as accurately defined in the borrowing discipline as it is in engineering.

Earlier, a quotation was presented which stated:

> "...a SYSTEM is whatever the person identifying it says that it is..." (10)

Consequently, the term "systems approach" means just what the user says it means...*provided* he defines it.

In a recent conference, the Aerospace Education Seminar on Educational Technology, eight persons were invited to speak "...on the crucial question of the Systems Approach to Education..."(20). One participant defined systems approach as "...total in that it integrates all factors that bear on the objective..."

Another said, "...we must examine every new device, every new systems approach, so that we can explore these innovations and apply them where they are applicable..."

A third remarked, "In this partnership, this systems approach, will teachers make any money? Is this just going to be a profit deal for industry, or are teachers going to make more money as we develop a systems approach?" With a perfect opportunity to correct an erroneous comprehension, this was the reply: "I think some teachers will make more and some will make less..."

One said: "...people are concerned about the fact that we really don't have objectives for education that are clearly defined so that we can design a system pointed at specific objectives. How can the systems approach be developed without such objectives? Someone who knows about systems says that they always have a feedback, a loop, and asks if this is possible in an educational operation. Others ask: 'Isn't there something better?' "

Later, in response to questions from the seminar audience, the participants clarified several points:

> "Systems analysis is a method, not a miracle. Simply put, it is a disciplined way of defining objectives, analyzing and evaluating alternative means, and putting means and ends together in the most sensible way..."
>
> "Systems analysis must begin from a clear definition of the objective to be attained...once the end result is defined, every element involved which contributes to attainment of the defined objective is isolated and analyzed in itself and in the essential relationships it has to the total process..."

And then restored chaos:

> "you might think of systems analysis as common sense---rigorously applied..."

This may be countered with the saying of a sage whose name is lost in antiquity:

> "Common sense is very uncommon."

Without doubt, the "systems approach" is a *good* thing and those who ignore it are in *bad* trouble. Blakeman, in applying the systems approach to marketing, refers to it as "architectronic," a structural design that imposes order, balance and authority upon a work or entity (21). Lawrence F. O'Brien, the Postmaster General, in a recent leter to an editor stated: "I believe the failure to employ the systems approach, along with inadequate financing, are two of the principal reasons why the postal service failed in the past to take full advantage of the remarkable technological developments of our age..." (22).

b. *Graphic Flowchart and Mathematical Models from Education and Training*.

(1) Hunt, in "Concept Learning" (1962) views human learning in mathematical terms (24). He reviews a large number of models which deal with *learning* as contrasted with *instruction*. Whereas nearly all previously described models deal with the learner from the instructional viewpoint, Hunt starts at the other end and examines more fundamental psychological aspects of learning. He looks at concept learning as decision-making situation likening it to information processing in computer systems. While there are no specific mathematical expressions which one might select and use in day-by-day education systems, Hunt does provide some quantification of what today is explored but uncharted terrain...all within the STUDENT subsystem.

(2) Stolurow (1965) presents a theoretical conception which led to the design of an adaptive cybernetic system for teaching and research on instruction. Attention is given to feedback and a flowchart model of the "Pre-Tutorial Decision Process" is presented. The information in the paper deals with the man-machine or learner-teaching machine relationship and is, consequently, at the micro or classroom level of an operating system. (25)

(3) The text "Programmed Instruction" (1965) describes several models of interest. One, by Tucker, is a generalized model; the second, the training subsystem patterned after the generalized model; feedback may be inferred. A third, based on Northrop Norair experience, depicts instructional program production from project definition to interfacing with instructional system; it is linear without feedback. The fourth, based on Sperry Polaris experience, is a flow of data thru 33 functions; like the Northrop model, it is linear

and devoid of feedback. However, the one which most clearly reveals a closed-loop system with feedback signal paths to maintain equilibrium is presented by Title Insurance and Trust Company, and was designed by Smith (26).

(4) The contributors to "Vocational Education," 1965 NSSE Yearbook, were outspoken in referring to the real-life problem:

Ginzberg: "Society...has swept the problem under the rug and held the teachers responsible for the poor preparation for work and life now offered to these adolescents. The challange goes beyond the school and involves management, labor, and government...the vast majority of communities have not even recognized the existence of the problem..."

Haskew and Tumlin: There is a major issue that "...existing institutionalizations of vocational education evolved from successful performance in an era which is now largely at an end..."

Walsh and Selden: "The high school has an obligation to prepare its graduated for employment as well as for higher education. Instead of facing up to this task, most high schools have organized their curricula primarily to prepare their graduates for college..."

In discussing a systems-and-procedures course for 12th grade: "The main problem is the lack of business teachers who have taken work or have had experience in this area...teachers in the vocational areas must be not only occupationally competent but expert in the use of distinctive teaching methods..."

Swanson and Kramer: "An institution which accepts the responsibility of training for employment should be aware of occupational training by business, industry, and the armed services and should assist its students to take advantage of such opportunities..."

Hamlin: "There is probably no school system in the United States that has a comprehensive statement of policy that could be called adequate..."

Brandon and Evans: "...it has been assumed (not tested) that teachers with ample occupational experience know the subject matter that they are expected to teach..."

Barlow: "Community involvement in advisory committee and in many other ways is necessary in the future program..."

While the contributors were able to identify most of the major problems and issues, one could not find in it any systems models which might suggest methodological solutions.

(5) Silvern (1965) performed an analysis of a proposed "Model System for Individual Learning" for a school district. (28) As a result, it was found that the proposal was completely infeasible. Steps towards the synthesis of a feasible system were outlined. Two flowchart models appear: "Flowchart Analysis of 'Model System for Individual Learning' " and "Synthesis of Relations in the Metasystem: California Public Education." Simple mathematical techniques were employed to measure time (t) as a parameter. While effectiveness (e) was also identified, it was unnecessary to measure e since t measurements were conclusive. Feedback signal paths characterized the models which involved 5th grade U.S. History and Spanish.

(6) Kaufman and Nunnelly (1965) present three reports (29). The first, "The Instructional System Approach to Training," (Kaufman, Corrigan, Nunnelly) describes a model which is closed-loop and includes feedback signal paths. A second model deals specifically with the preparation of an instructional system for the U.S. Air Force. This paper is the foundation for two others, "The Instructional System Approach to Maintenance Technical Training: Development and Implementation Model" (Nunnelly, Clemmer, Corrigan, Kaufman); "Instructional System Approach to Flight Crew Training," (Wallis, Ewert, Kaufman).

(7) While the title of a 1966 NSSE Yearbook, "The Changing American School," held promise of success in finding education models, the text was bare of this kind of information (30).

(8) Smith in "The Design of Instructional Systems" presents a general model of an instructional system (31). The functions are narratively described; feedback may exist but this is not clear from the model.

(9) Hulett (1966) reviews the earlier efforts of modeling by Fearing (1953), Newcomb (1953), Schramm (1954), Kirk (1964), and by the Stanford Group (1964). He graphically describes "A Block Diagram of a Social Act Between Two Interacting Individuals, According to Interactionist Principles" (32). This model has intrapersonal and interpersonal feedback signal paths. He also presents "The Covert Rehearsal of Either Participant in a Social Act, According to Symbolic Interactionist Principles" in typical flowchart form. Covert Rehearsal, shown in some detail, is really one of several subsystems revealed in the first model. "Symbolic Interactionism" is a term in sociology originally called social behaviorism by Mead. The models are based in part upon Sears' dyadic instigation-action sequence model (1951). By integrating this social act model of a person with other models of the learner, etc., it should be possible to graphically describe the social-psychological subsystem known as STUDENT. However, this would be at the micro operating level in a system.

(10) In a paper presented to the Operations Research Society of America (1966) mathematical models or "econometric models" of education by Tinbergen and Bos (1965) are described. Against this background, OECD in 1965 decided to pursue further use of models in educational planning (33).

The paper categorizes models in this manner:

a. the educational system in terms of students, teacher and the economy (such as Tinbergen and Bos, "Econometric Models of Education")

b. the educational system in terms of administration, school location, student transportation, construction, scheduling, teacher recruitment and allocation of funds (such as the work of Holz in scheduling at Merrimac Community College, St. Louis, Mo.)

c. evaluation for the educational policy-maker of relative merits of policies, criteria for fund allocation, costs and effects of proposed educational reforms, effectiveness of decision-making structure, etc.

In 1966, a number of papers were presented, among them: "The Development of Computable Models of the British Educational System and their Possible Uses," Armitage and Smith; "A Mathematical Model of the Norwegian Educational System-A Case Study," Thonstad; and "Projection Models of the Swedish Educational System, Forecasting Institute of the Swedish Central Bureau of Statistics." These are essentially student flow models used for forecasting; a, above. A paper by Alper, "Introduction of Control Concepts in Educational Planning Models," is based upon systems engineering techniques. In the second category, b above, these papers stand out "Training Policies Under Conditions of Technical Progress: A Theoretical Treatment," von Weizsäcker; "General Optimization Model for the Economy and Education," Bénard. Dressel in "Comments on the Use of Mathematical Models in Educational Planning" refers to Michigan State University experience. A study dealing with systems analysis techniques applied to educational problems in Yugoslavia, 1965, suggests the application of graph theory and network analysis to that problem. The paper itself was a summary report of activity and not a technical report delineating models in detail.

(11) Silvern and Silvern (1966) present a "Graphic Analog of the Public Education K-12 System" for the purpose of identifying those subsystems involved with CAI activity: "CAI Instructional programming begins in subsystem 21.0 (Perform Human Activity Analysis) and the main development efforts are in 10.0 (Develop Curriculums) and 16.0 (Develop Instructional Materials) (34).

There are 23 subsystems of which 9 are outside the school district and constitute the non-school real-life situation. Four feedback signal paths into the school district and 2 within the school district are labeled as feedback.

(12) Silvern (1966) analyzes the Compton Union High School District SPS (Special Projects System) (35). Using systems analysis techniques, a flowchart model is developed which identifies all critical elements in the district, involving 3 high schools and 7 junior high schools. A second model, the synthesis of a proposed occupational education subsystem is produced,

and from it is localised a malfunction which would impede forward progress in implementing this subsystem. Using this data, an ESEA Title III proposal of an innovative nature is developed and later funded by the U.S. Office of Education (36, 37, 38).

(13) Allport (1967) in a technical paper at an exceptionally high level of reading difficulty and comprehensibility, describes a number of concepts which may bear on the micro-micro level of STUDENT activity (39). He models an organism as having input, output, result and feedback functions. At this point he raises a question: "Has the organism, both morphologically and as ongoing, some characteristic spatiotemporal pattern or 'geo--metry' of its own? Could one test this idea by cartographic methods, that is by making a theoretical drawing of such a pattern, and then comparing it, as a hypothesis, with organismic and behavioral facts?" While he refers to feedback, this is neural or humoral or proprioceptive and, because of terminology noise, it is difficult to interpret the meanings. However, a crude flowchart model, "Behavioral-act cycle illustrating time-ordered CR compounded lay," appears when deciphered to be a closed-loop, sequential flowchart of functions in a chronological time continuum. In Allport's view, he envisages the organism not as merely "...an aggregate of elements that bind one another, but as an enduring and lawful structure of events..." One illustration refers to the probability "that school systems...would meet in kind the needs of...children... combined with the amount if such education (number of schools or teachers) that would be available..." It appears that Allport's view is somehow involved with other notions of data aquisition and processing in biology and medicine and, shorn of the terminology barrier, may find a place in a general systems theory, a field theory, of organisms (23).

(14) Silvern (1967) presents a complex flowchart model: "Training: Business & Industry" system (9). An expansion of a earlier and more primitive model, this incorporates such new functions as: idemtify real-life invention and innovation, perform basic synthesis, perform job synthesis, produce CAI processor, develop CAI course, and produce computer program. Feedback both from without and inside the "system" is identified and labeled.

(15) Contributors to "Automated Educational Systems" (1967) describe the total systems approach (Sims), concept of total systems in education (Alcorn), a national educational information system (Grossman), concept of regional educational data processing (Howe), and similar topics. A number of flowchart models appear. One, by Howe, describes *administrative* functions in a school or school district; feedback inferred but not identified. Another, by Silvern and Silvern, depicts the sequence of units in a 94-hour course on Computer-Assisted Instruction; it is entirely linear without feedback. Others, by Uretsky, reveal computer processing sequences in the PLATO CAI system; these have feedback loops as does most computer logic but deal at a micro level approximating the "statement" in Figure 2, page 5 (40).

These 15 contributions represent only a percentage of the total number of similar contributions between January 1965 and June 1967. Many of these are not published, they appear in specialized journals or periodicals, or they are for the internal use of a particular organization and difficult to acquire. What is disturbing is that all of the published material falls neatly into four categories with the indicated percentages:

(a) testimonials and oblique references to system, instructional system, systems analysis, systems approach but no clear statements of procedure, formularization or modeling (95%)

(b) insightive descriptions and technically correct applications but no clear statements of procedure, formularization or modeling (3%)

(c) clear statements of procedure or a model which are at the STUDENT-MACHINE level, the STUDENT level, or a similar *micro* level other than at the school or school district operating level (1%)

(d) clear statements of procedure or a model at the school or school district operating level (1%)

Thus, the main source of useful published and available experience totals about 1% of the whole. *One may conclude that we should not rely solely upon what techniques are known and used by the rank and file educator or educational researcher.*

c. *Systems theory and techniques in other disciplines*. The physical sciences, as might be surmised, evolved systems engineering within the past 25 years. The principles of feedback are inherent in the field of "control." Gibson (1965) makes the point that, prior to the 1940's, the field of *control* was characterised by a primitive, empiric nature (41) in fact, Nyquist, Bode, and Minorsky were working in the 30's but years passed before their work was appreciated by the average engineer. Gibson states: "In the classic period, systems analysis was based on theory...upon the solid rock of linearity... the frequency domain and the La Place transform were used exclusively... the frequency domain approach dominated the field of control through the 1950's...more than 90% of the systems in use today were designed with these concepts... We had a perfectly acceptable theory so long as we confined ourselves to linear systems...we ignored tough problems. We ignored nonlinear systems, systems with parameters that vary with time, systems which by their nature prevent complete a priori knowledge of their behavior, systems that work in conjunction with human operators, etc. In short, we ignored much of the real world..." He went on, "...early workers in modern control had by now convinced the field that conventional engineering design by repeated trials until all system specifications were met could be replaced by exact optimisation, provided the problem is properly put...a new theme was being sounded...the automatic control problem...is a very complex problem in the calculus of variations...we are now living through a fertile moment in scientific history, one in which mathematics draws nourishment form its roots in physical reality...the dialogue between mathematics and systems engineering has been established..."

Lewis (1966) is also concerned with systems engineering (42). However, he examines it from a different perspective, *communications* rather than control: "By 1960, communication had broadened to cover anything that one could do electronically to information...members of the newspaper and advertising and television industries had begun to describe their work as communications; then we discovered the word 'system,' and suddenly by some mysterious process many of us became systems engineers...communication is something that happens between one mind and another...it also includes the process of education..."

Lewis expresses his cynicism: "For more than five years, I headed groups with the word 'systems' in their titles and I still do not know the answers (what is a systems engineer?...etc.) -- nor have I met anyone else who has convinced me that he does either. In spite of all this, we have successfully built many systems... Whether we understand it or not we must admit that effective systems engineering is going on..."

On education, Lewis states: "...educators might receive suggestions and guides to thought by considering their problems in terms of communication concepts and models... the application I am now advocating is of the concepts and ideas of communication rather than the hardware..."

Romnes, in an IEEE interview, approached this from the *management* viewpoint (43): "...increasingly, the ability to manage complex engineering undertakings depends on what we have come to call systems engineering. Today, I'm afraid, the term is used in more places than it is fully understood or the art practiced. Systems engineering, if it is to be more than a merchandising catchword, requires engineering effort of the most rigorous sort..." On "systems approach," he said: "...a lot of valuable engineering work gets done by sheer concentration on detail without a thought to the task as a whole; but someone has to think about how the pieces fit together to make this whole... over the years this sense of the whole, or the systems approach, has become much more important as projects have assumed greater complexity and scale..."

The *London Sunday Times* is apparently also convinced of that aspect of system known as *synergism*. In an article on Beatlemania (the Beatles phenomenon) in 1966, it was reported that: "...this is a rare team of which the whole is really much more than the sum of the parts..." (44).

As witness to the newness of this field, a new quarterly journal, *Mathematical Systems Theory*, was announced for publication in 1967 (45).

However, one of the most consistently valuable sources of technical information has come from a group known as the Society for General Systems Research. Toda and Shuford (1965) present a formal theory of structure in the logic of systems and, if analysis is substituted for "decomposition," synthesis for "composition," objects, actions and information for "physical objects, processes and concepts" then there is an excellent resemblence to Silvern's terminology (46a, 10). However, Toda and Shuford go much further in establishing eight theorems which are proposed as truths to be tested and validated.

Klír (1965) describes the general system as a methodological tool (46b) and Barthel (1965), inspired by some of Rapoport's work on the Constant Gain Learner and the Perfect Learner, presents a mathematical model and a computer simulation of the latter (46c).

Rapoport (1966) discusses the mathematical aspects of general systems analysis (46d): "The power and the scientific fruitfulness of general system theory depends on whether in fact there exists properties common to all systems, and if so whether important consequences can be derived from these properties..." Here is a synopsis of his paper:

(1) the differential equation, a precise statement about how certain quantities and their rates of change are related, was successful in classical physics.

(2) classical physics was an entirely *mechanistic* view of the world.

(3) a system of differential equations could describe interdependencies if the equations are linear but could not in nonlinear systems by any known general methods.

(4) many phenomena remained outside the scope of mathematized (completely rigorous) science.

(5) one of the most important of these phenomena involved "organized complexity," which mathematically is viewed as a set of objects or events whose description involves many variables, among which there are strong mutual interdependencies, so the resulting equations cannot be solved piece-meal as in the case of classical mechanics.

(6) the living organism is the most obvious example of "organized complexity" resisting attempts to represent it mechanistically.

(7) mechanistic method of analysis includes all forms of analysis seeking to explain the working of a whole in terms of the working of its parts. It is a view in which the whole is the sum of its parts.

(8) antithetical is a view which makes a whole the starting point of investigation. Behavior of the whole described by laws which are primary. Behavior of the parts is deduced from laws governing behavior of the whole. Known as *organismic*, this prevails in some biological and social science areas.

(9) general system theory, in its mathematical aspect, fuses the *mechanistic* and *organismic* so as to utilize the advantages of each.

(10) a system is not merely a totality of *units* each governed by laws of causality operating upon it, but rather a totality of *relations* among the units.

(11) emphasis is on "organized complexity;" addition of a new entity introduces not only the *relation* of this entity to all others but also modifies relations among all other entities.

(12) degree of organization becomes the central concept; theories engendered by this view are called contributions to general system theory.

(13) cybernetics, a discipline cutting across the established disciplines of science, is a mathematical method developed to describe "organized complexity."

(14) central in cybernetics is the concept of information. Information is the unifying concept in organized systems whose behavior is under control to achieve pre-set goals.

(15) control is accomplished by processes involving coding, storage and transmission of information.

(16) the organismic notions of goal-seeking behavior are derived from the mathematical structure of systems of organized complexity.

(17) "amount of information" is defined mathematically and can be applied to all phenomena involving goal-seeking behavior.

(18) the Second Law of Thermodynamics states that if a physical system is isolated from its environment, the amount of entropy in the system can only increase towards a maximum; never decrease.

a. physically, the total amount of energy in the system remains constant (First Law of Thermodynamics) but free energy, energy which can do work on the environment, can only decrease; an isolated system's energy is degraded--becomes heat energy.

b. statistically, isolated systems tend to drift from less probable ones to more probable ones, from organized states to more chaotic states.

(19) Wiener's understanding of the mathematical connection between entropy and information can be viewed as: an increase in entropy is a destruction of information; information can reduce entropy.

(20) Maxwell formulated an idea: a being with perceptions sufficiently keen to observe and control positions and velocities of single molecules could reverse the process of increasing entropy (disorder) even in an isolated system...a violation of the Second Law.

(21) the fallacy revealed by Szilard and Brillouin was that the being had processes going on within him which must be considered in computing the total change in entropy; if the being intervenes from outside the system, the system is no longer isolated.

(22) von Bertalanffy formulated his approach to general system theory based on the fundamental distinction between isolated and non-isolated systems, leading to a crucially important insight into the nature of life.

(23) mathematics is devoid of content expressing only the *relational* features of a situation, thus qualifies as the language of general systems theory.

(24) mathematically, a system is any portion of the world which at any given time can be described by ascribing specific values to a number of variables; the totality of such values constitutes a *state* of the system.

(25) the more complex a system, the more variables are required to describe a state.

(26) the more organized it is, the more it is equipped to resist disturbances in pursuing a goal.

(27) organization and complexity are correlated.

(28) mathematically two systems closely related will have close similarities in their mathematical models.

(29) how accurately a mathematical model can describe a real system is important but not central to a general system theory; that problem deals with *content* while general system theory is concerned with *structure* as defined by the relations which parts of a system have to each other.

(30) mathematical general system theory provides descriptions of three aspects of systems in abstract mathematical language: structure, behavior and evolution.

(31) recently, increasing emphasis has been put on probablistic or stochastic aspects of processes. Models are based on an assumption that transitions from state to state are governed by probabilities. This raises the question of whether such a system is still "organized complexity" based of well-defined contingencies of events rather than determined by chance.

(32) the distinction between deterministic and probablistic contingencies is not sharp; in a large population of systems, probabilities became frequencies and determinism is reestablished.

(33) probabilistic and stochastic models puts the conceptual apparatus of those theories at the disposal of general systems theory.

(34) limitations: structural similarities between two or more systems are valid only if the corresponding mathematical models are sufficiently faithful representations of the systems.

(35) formulation of a mathematical model is often an extremely difficult task; some systems defy all attempts at mathematical descriptions.

(36) mathematical general system theory is an important addition to the conceptual repertoire of the scientist rather than a method destined to drive all the older methods into obscurity.

Because the social and behavioral sciences in general, and instructional systems in particular, present completely new problems to the systems engineer or analyst, some time must elapse before techniques are developed which can be applied. We should continuely look at non-behavioral science activity to see if techniques there have transfer value for educators. The solutions in the section to follow fall into this major category.

Platt (1966) et al, in "A Basic Plan for a Highway Transportation Systems Study," speaks of an instrumented driver, in instrumented car, on an instrumented highway and presents a highway transportation system flowchart model which compares favorably with the school district or macro operating level (47). Platt and his colleagues have been building up to this model over a long period of years during which a major concentration was first instrumenting the car subsystem to measure human performance (48, 49, 50).

Knoop (1966) in a study dealing with the automatic monitoring of human performance, relates the instructor, trainee, simulator and computer. If real-life is substituted for the simulator, one might see human performance of both teacher and student measured against system criteria at the classroom or school macro operating levels (51).

Queing model techniques as described by Barton et al (1964) and Purvis et al (1965) for system manning and support are of interest if one considers subject-matter content and other occupational information in the real-world as following a cyclical queue between school and society (52, 53). This would be at the macro operating level.

Decision-making and predecisional theoretic techniques as broadly presented at an Air Force Symposium, "Predecisional Process in Decision Making," is of interest if one considers the instructor in his classroom, and outside it, as an information processor with "concrete" or "abstract" characteristics (54). These characteristics are described by Lanzetta and Sieber (1964) in a paper, "Predecisional Information Processes: Some Determinants of Information Acquisition Prior to Decision Making," presented at the symposium. The paper deals with the "search" aspect of human performance and such questions as: under what conditions does an organism instigate search for information, what variables control the direction and redirection of search activity, how does the organism utilize the information acquired, how are tentative decisions generated and modified as new information is obtained, what variables control the termination of search and lead to a committment to decide?

The term "neuromine" refers to a computational element used conceptually in biological information processing networks; Colomb (1966) conceives a geometrical model (55). Griffith and Bolen (1967) viewed the neuromine network as an adaptive control mechanism using two basic feedback concepts (56). This may bear on a school situation when one considers the teacher interacting with the non-teacher environment as the other subsystem at the micro operating level.

Probably one of the more promising avenues may turn out to be general theory of directed graphs by Harary et al (1965) and Flament's interest (1963) in applying graph theory to behavioral science holds a means of quantifying flowcharts (57,58). This has also been described by Chestnut (1965) looking at the problem as a systems engineer in his chapter on Modeling and Simulation, involving the engineering transfer function (59). The most recent (1967) exploration of modeling, or cybernetic modeling, is a text by Klír and Valach in which nearly all significant practical methods of mode are logically studied (60).

Having briefly reviewed the most recent literature dealing with flowchart and mathematical modeling, it is appropriate to move next to the method employed in this particular study.

B. METHOD

1. Data Collection and Analysis

Information was obtained from these sources:

a. occupational teachers

  (1) from vocational, technical and comprehensive high schools in Compton, El Segundo and Los Angeles, California; Philadelphia, Pennsylvania; Bridgeport, New Haven, Norwalk, Stamford, Stratford, and Westport, Connecticut; Albany, New York, and Oceanside, New York; Austin, and Fort Worth, Texas.

  (2) by personal interview singly and in groups, on an informal basis.

  (3) approximately 45 such teachers were in the sample.

b. supervisors of occupational instruction and directors of vocational education (or the equivalent)

  (1) from high schools in Compton, and Los Angeles, California; Philadelphia, Pennsylvania; Bridgeport and New Haven, Connecticut; Fort Worth, Texas.

  (2) by personal interview singly and in groups, informally.

  (3) approximately 12 such management personnel were in the sample.

c. state departments of education; bureau chiefs, division heads, regional supervisors, regional technical personnel, and university staff

  (1) California

    (a) from University of California, Los Angeles; Division of Vocational Education. From State Bureau of Industrial Education; Los Angeles Regional Office.

            - (b) by personal interview, informally.

        - (2) Indiana
            - (a) from Indiana University; Division of Distributive and Vocational Education.
            - (b) by personal interview, informally.

        - (3) New York
            - (a) from State Department of Education; Bureaus of Home Economics, Business & Distributive Education, Agricultural Education, Secondary Education Curriculum Development, Occupational Education Research and Evaluation, Continuing Education, Adult and Vocational Education and Educational Communications. From State Department of Education Regional Office, New York City: Industrial Teacher Education.
            - (b) by personal interview singly and in groups, informally.

        - (4) Texas
            - (a) from University of Texas, Division of Extension, Industrial Education Department.

    - d. university faculty not affiliated with a state department of education function
        - (1) from Indiana University; departments of Correspondence Education, audio-visual education. From Ohio State University; Industrial Education Curriculum Project. From Texas Chriatian University; Instructional Systems Institute, Dean's Office. From University of Texas; Department of Educational Psychology. From George Washington University; School of Education.
        - (2) by personal interviews, informally.

    - e. county departments of education having occupational education functions
        - (1) from Los Angeles County Superintendent of Schools' representative.

  - (2) by personal interview, informally.

- f. occupational counselors in secondary schools and school districts
  - (1) from Compton, California and Stratford, Connecticut.
  - (2) by personal interview, informally.
- g. training directors in government agencies, non-military and military
  - (1) from Office of Local Government; State of New York; Office of the Assistant Secretary of Defense (Manpower), Department of Defense.
  - (2) by personal interview, informally.
- h. training directors and operating managers in private business and industrial companies, hospitals, etc.
  - (1) from a large number of such organizations but notably from Sikorsky Aircraft, Bridgeport, Connecticut, where the Training Director and four Sikorsky line supervisors responsible for design, drafting and electronics conferred in the presence of 3 high school drafting teachers from Joel Barlow H.S., Redding; Bunnell H.S., Stratford; and Stratford H.S., Stratford.
  - (2) by personal interview singly and in groups, informally
- i. officers of professional societies
  - (1) from the President, Connecticut Industrial Arts Association; and Editor, Training Director's Journal, American Society for Training and Development.
  - (2) by personal interview, informally.
- j. 12th grade students, recently graduated students, those employed and those unemployed.
  - (1) from a large number of secondary school districts in the states of Arizona, California, Connecticut, Indiana, New York, Pennsylvania and Texas.

(2) by personal interview, informally.

k. experts in school-industry relationships

Appendix I represents "How New Content Elements Enter Into Vocational Courses;" a position paper invited for this project.

The project examined samples in these fields primarily:

electronics: radio, television
drafting; machine drafting and design
commercial art

However, those individuals constituting the entire sample specialized in a wider variety of occupational fields:

aeornautics
agriculture
art and philosophy
automotive
automotive air conditioning
business
commercial art
computer technical education
drafting
electronics
firemanship
home economics
machine trades
mechanical and architectural drafting
oil industry trades
physical science
restaurant practice
wood shop

Information collected during interviews was documented as written notes rather than by tape recordings since it was believed the interviewees would speak more freely under those environmental conditions. Whenever possible, the Project Director was accompanied by one ETC staff member and the latter took notes. This technique afforded a post-interview discussion between the two.

The analyses which were performed on the data collected had these objectives:

(a) identify elements which exist outside the secondary school subsystem from which information flows through a feedback signal path into the school.

(b) select from the elements those which are believed to have a measurable influence upon the curriculum.

(c) categorize, relate and combine or restructure these elements into meaningful relationships thereby creating a model.

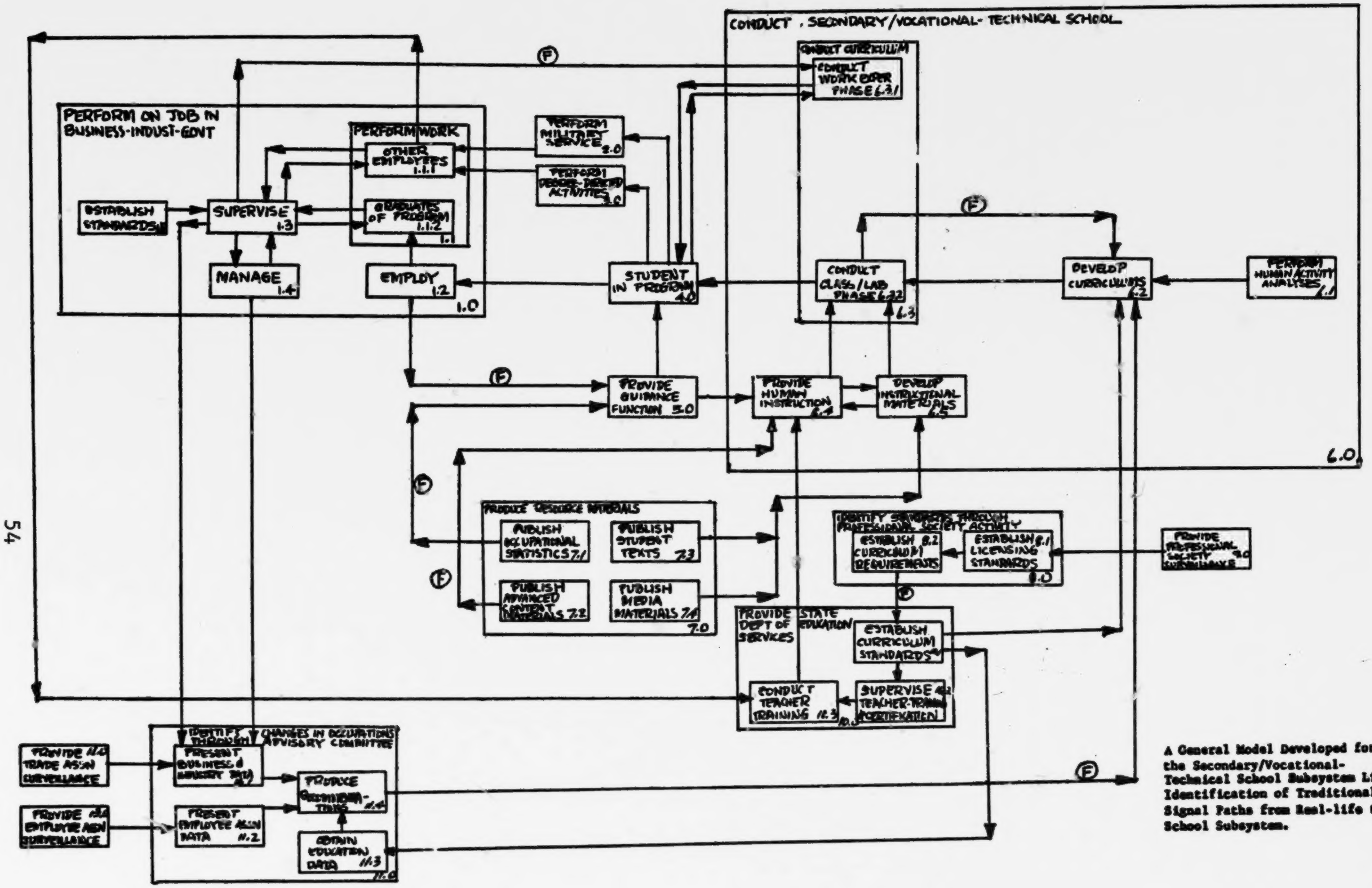
(d) analyze the restructured model.

(e) evaluate the restructured model.

The original proposal for this project consisted of the flowchart model shown in Figure 3, "A General Model Developed for the Secondary/Vocational-Technical School Subsystem Limited to Identification of Traditional Feedback Signal Paths from Real-Life to the School Subsystem."

Six major feedback signal paths were identified in the proposal model:

	From	To	Nature of Feedback
(1)	1.2 5.0 5.0	5.0 4.0 6.4	Employee acquires occupational experience; leaves business, industry or government employment; becomes secondary school teacher; provides occupational guidance to student; bases instruction upon employment experience. Feedback supposedly changes curriculum content.
(2)	7.1 5.0 5.0	5.0 4.0 6.4	Occupational statistics are generated as a resource from outside the school system; are acquired by an occupational teacher who uses this to provide occupational guidance to student; bases instruction upon occupational statistics. Feedback supposedly changes curriculum content.
(3)	7.2	6.4	Content materials, such as handbooks, catalogs, manuals, technical data sheets and other printed matter (excluding films, strips, etc.) which are not prepared for instructional purposes in a secondary school, are acquired by an occupational teacher who uses these to update his course content and himself. Feedback supposedly changes teacher's recency of knowledgeability.
(4)	11.4	6.2	Occupational Advisory Committee, using data provided by management and employee members, produces recommendations which influence the


CONDUCT, SECONDARY/VOCATIONAL-TECHNICAL SCHOOL
6.0
CONDUCT CURRICULUM
CONDUCT WORK EXPER PHASE 6.3.1
CONDUCT CLASS/LAB PHASE 6.3.2
6.3
DEVELOP CURRICULUMS 6.2
PERFORM HUMAN ACTIVITY ANALYSES 6.1
PROVIDE HUMAN INSTRUCTION 6.4
DEVELOP INSTRUCTIONAL MATERIALS 6.5
PERFORM ON JOB IN BUSINESS-INDUST-GOVT
1.0
PERFORM WORK
OTHER EMPLOYEES 1.1.1
GRADUATES OF PROGRAM 1.1.2
1.1
ESTABLISH STANDARDS
SUPERVISE 1.3
MANAGE 1.4
EMPLOY 1.2
PERFORM MILITARY SERVICE 2.0
PERFORM DEGREE-DIRECTED ACTIVITIES 3.0
STUDENT IN PROGRAM 4.0
PROVIDE GUIDANCE FUNCTION 5.0
PRODUCE RESOURCE MATERIALS
PUBLISH OCCUPATIONAL STATISTICS 7.1
PUBLISH STUDENT TEXTS 7.3
PUBLISH ADVANCED CONTENT MATERIALS 7.2
PUBLISH MEDIA MATERIALS 7.4
7.0
IDENTIFY STANDARDS THROUGH PROFESSIONAL SOCIETY ACTIVITY
ESTABLISH CURRICULUM REQUIREMENTS 8.2
ESTABLISH LICENSING STANDARDS 8.1
8.0
PROVIDE PROFESSIONAL SOCIETY 9.0
PROVIDE STATE DEPT OF EDUCATION SERVICES
ESTABLISH CURRICULUM STANDARDS
SUPERVISE TEACHER-TRAINING CERTIFICATION
CONDUCT TEACHER TRAINING 10.3
10.0
IDENTIFY CHANGES IN OCCUPATIONS THROUGH ADVISORY COMMITTEE
PRESENT BUSINESS & INDUSTRY DATA
PRESENT EMPLOYEE ASSN DATA 11.2
PRODUCE RECOMMENDATIONS 11.4
OBTAIN EDUCATION DATA 11.3
11.0
PROVIDE TRADE ASSN SURVEILLANCE
PROVIDE EMPLOYEE ASSN SURVEILLANCE
F
F
F
F
F
F
F

A General Model Developed for the Secondary/Vocational-Technical School Subsystem Limited to Identification of Traditional Feedback Signal Paths from Real-life to the School Subsystem.

Figure 3

			occupational curriculums in the particular secondary school. Feedback supposedly *changes* curriculum content, *eliminates* an entire course, *institutes* a new course.
(5)	9.0 8.1 8.2 10.1 10.2	8.1 8.2 10.1 10.2 10.3	Professional Society, using data required through constant surveillance of its membership, establishes licensing standards and curriculum requirements which influence the State Department of Education. This influence causes changes in occupational teacher certification criteria and these are reflected in mandatory or voluntary teacher training course content which ultimately impact upon occupational teachers being prepared for certification. Feedback supposedly produces content updating in the teacher through the teacher training function.
(6)	1.3	6.3.1	Student in school is engaged in a work experience program during which he is employed on a real-life job. His supervisor on the job provides nominal management control--the student's behavior is changed. Any improvement is initially in the individual student but it may also be an improvement in the program itself if the supervisor's influence can reach into the school curriculum, through personal contact. Feedback of this type supposedly produces content updating.

2. Model Synthesis

The model was restructured, evaluated and an improved model synthesized as the result of each major confrontation with input data from real-life. This iteration was *pure* synthesis: combining previously unknown or unidentified elements and their feedback signal paths.

The technique of qualitative synthesis, used in this project, was developed by the contractor and is described elsewhere (4, 10, 61). The model is closed-loop. It has feedback signal paths from real-life into the school subsystem. These signals produce an (input) error signal *within the instructor* which is reduced and eliminated through a *conscious* effort by him to change his behavior (output).

In Figure 4, we see an over-simplified and relatively incomplete model which corresponds to the PROVIDE HUMAN INSTRUCTION 4.6 subsystem in Figure 3.

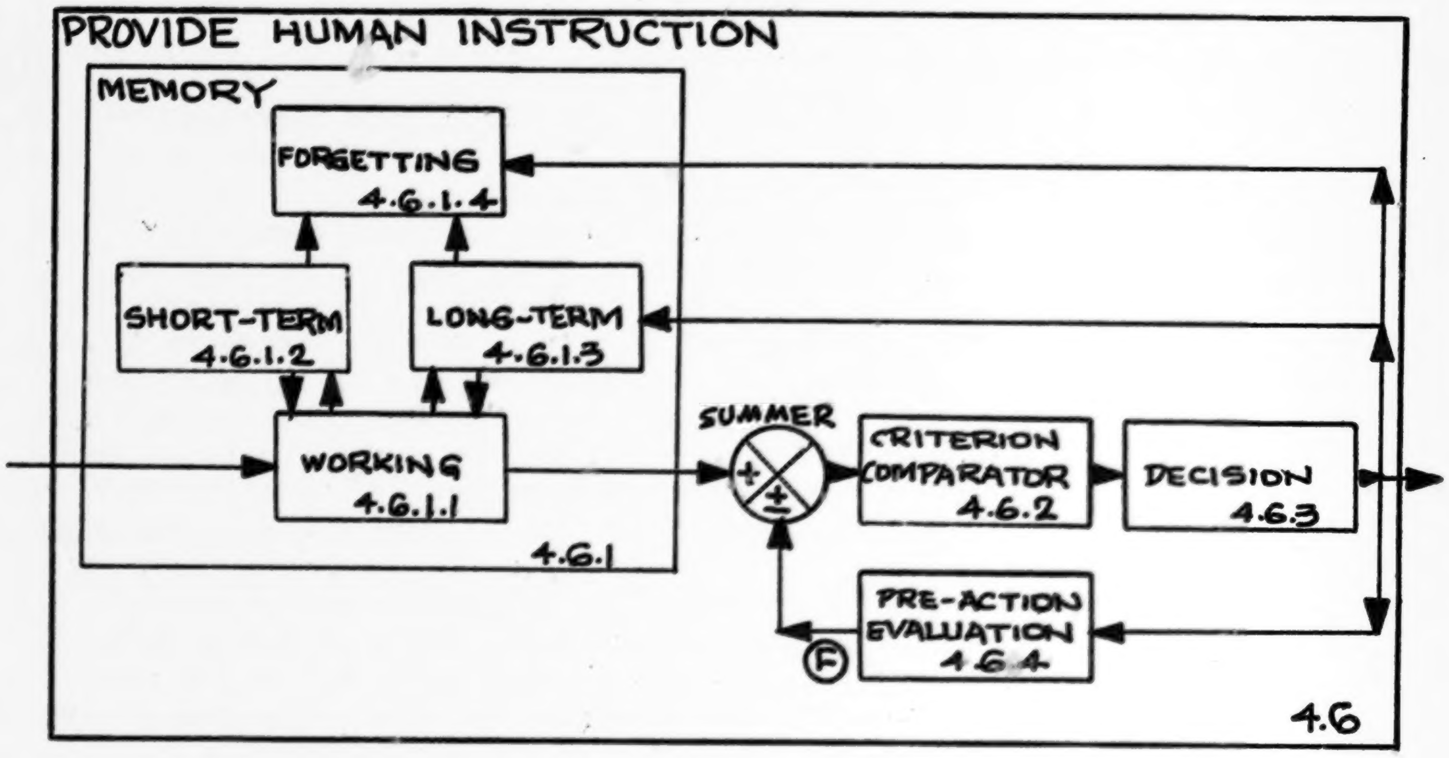
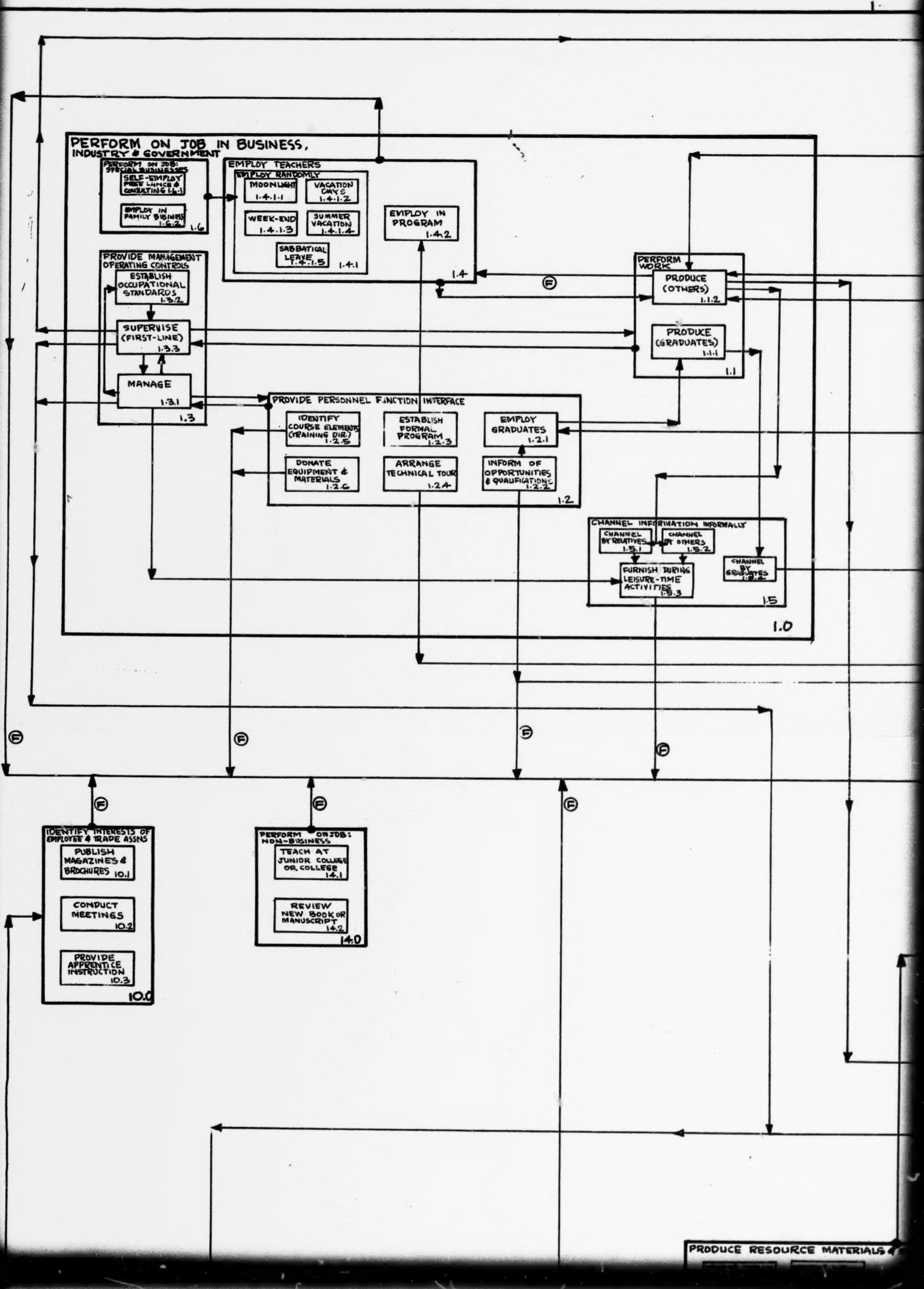
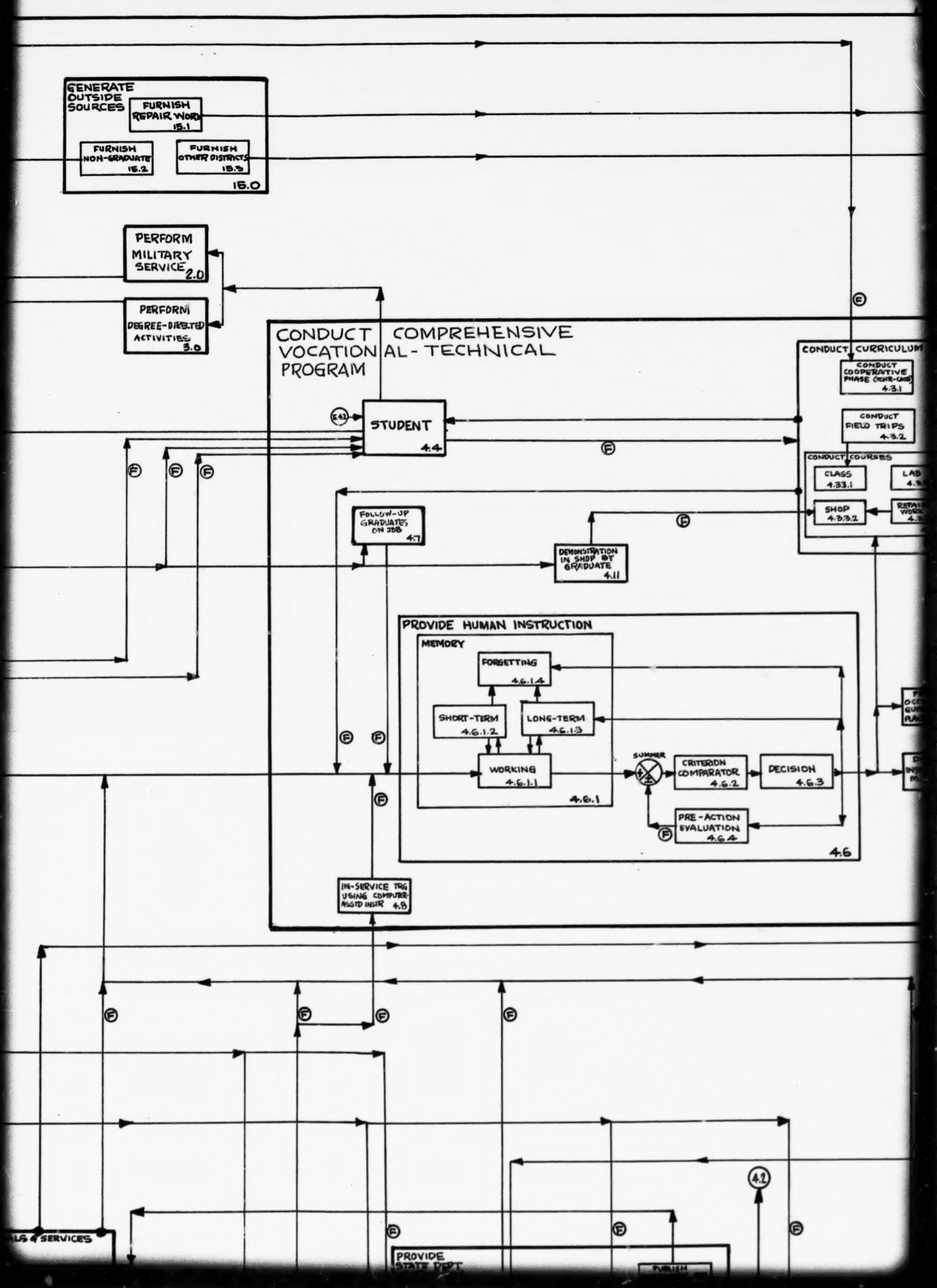

PROVIDE HUMAN INSTRUCTION
MEMORY
FORGETTING 4.6.1.4
SHORT-TERM 4.6.1.2
LONG-TERM 4.6.1.3
WORKING 4.6.1.1
4.6.1
SUMMER
+
±
CRITERION COMPARATOR 4.6.2
DECISION 4.6.3
PRE-ACTION EVALUATION 4.6.4
F
4.6

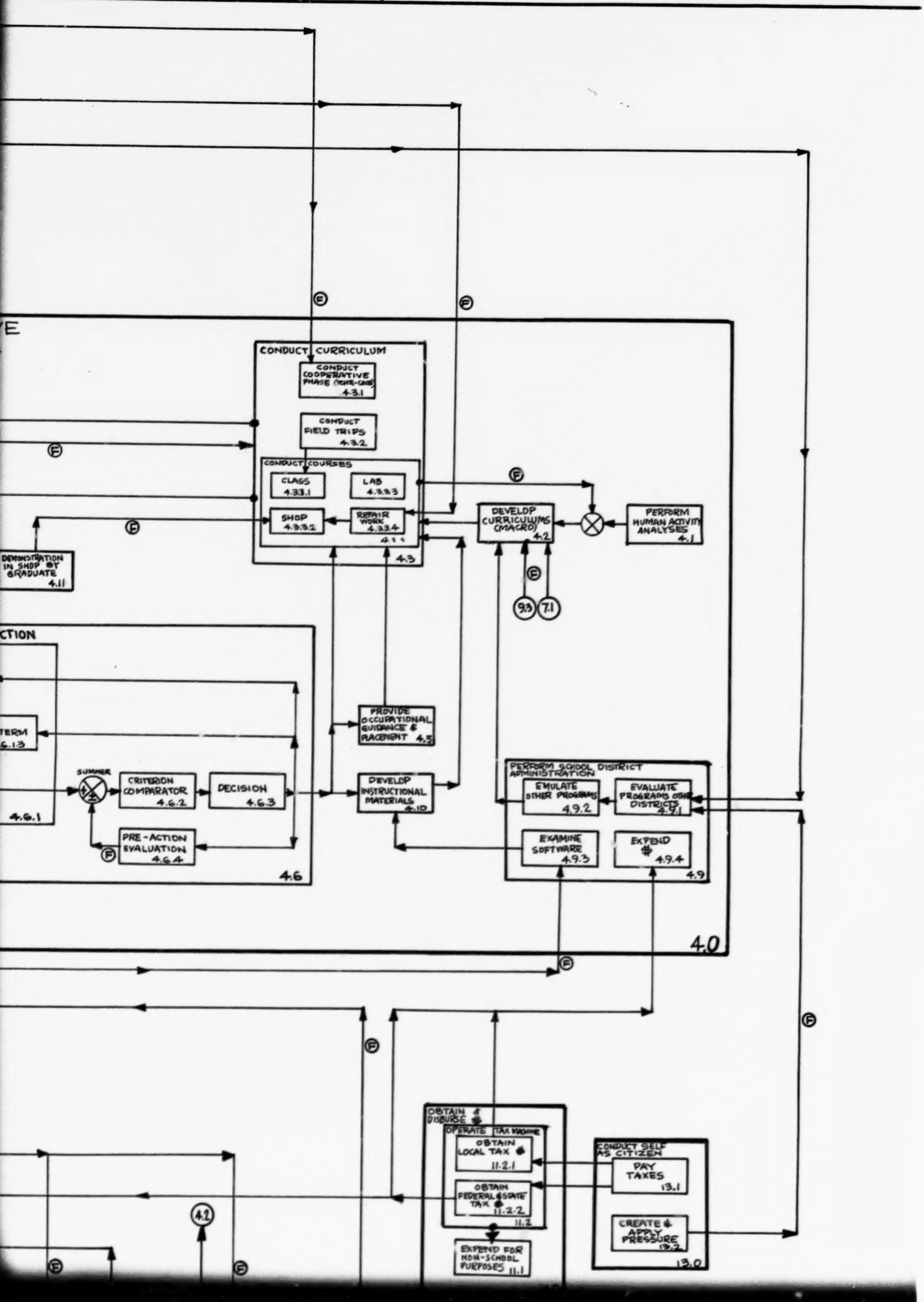
FIGURE 4

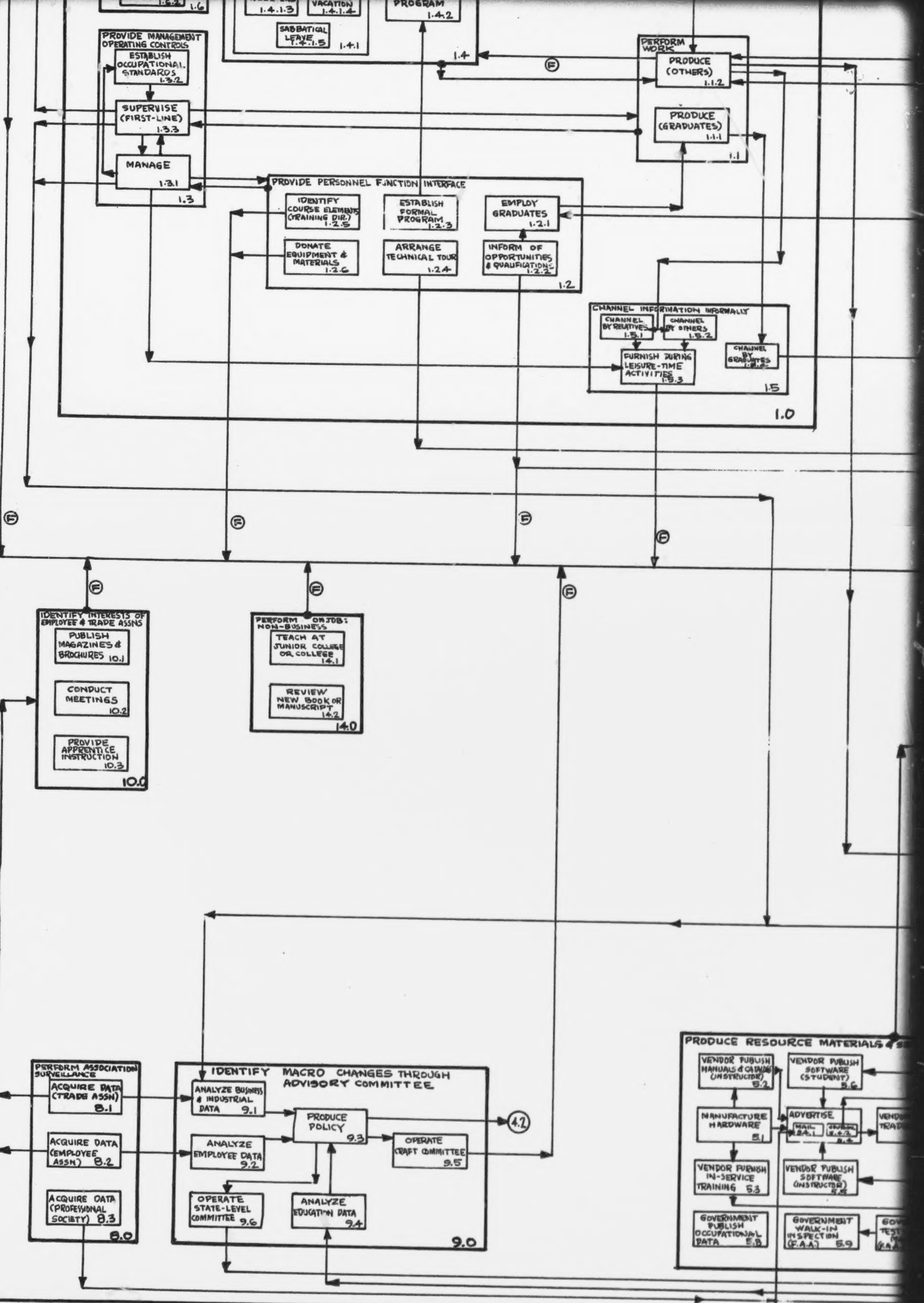
The short- and long-term memory is based in part upon Baker's conceptualization (62).

In general, information comes to the instructor and enters his working memory (4.6.1.1). Four decisions are possible: take immediate action (4.6.2), place in short-term memory (4.6.1.2), place in long-term memory (4.6.1.3), assign to a conscious discard or forgetting function (4.6.1.4). If in working memory (4.6.1.1), the data moves to the criterion comparator (4.6.2); also moved to this function is the instructor's long-term criteria for the particular problem being processed. After comparison in (4.6.2), a decision (4.6.3) is produced which in effect sends the solution on to another subsystem, to the pre-action decision evaluator (4.6.4) or to long-term memory (4.6.1.3). Any modifications of the decision are fed back to the summer where an error signal is generated. The summer will produce an input to (4.6.2) resulting from the original input and either positive or negative feedback (4.6.5). In this subsystem, the signals are considered as fast and the transfer functions as possessing certain time variant delay characteristics.


1
PERFORM ON JOB IN BUSINESS, INDUSTRY & GOVERNMENT
PERFORM ON JOB: SPECIAL BUSINESSES
SELF-EMPLOY FREE LANCE & CONSULTING 1.6.1
EMPLOY IN FAMILY BUSINESS 1.6.2
1.6
EMPLOY TEACHERS
EMPLOY RANDOMLY
MOONLIGHT 1.4.1.1
VACATION DAYS 1.4.1.2
WEEK-END 1.4.1.3
SUMMER VACATION 1.4.1.4
SABBATICAL LEAVE 1.4.1.5
1.4.1
EMPLOY IN PROGRAM 1.4.2
1.4
PROVIDE MANAGEMENT OPERATING CONTROLS
ESTABLISH OCCUPATIONAL STANDARDS 1.3.2
SUPERVISE (FIRST-LINE) 1.3.3
MANAGE 1.3.1
1.3
PERFORM WORK
PRODUCE (OTHERS) 1.1.2
PRODUCE (GRADUATES) 1.1.1
1.1
PROVIDE PERSONNEL FUNCTION INTERFACE
IDENTIFY COURSE ELEMENTS (TRAINING DIR.) 1.2.5
ESTABLISH FORMAL PROGRAM 1.2.3
EMPLOY GRADUATES 1.2.1
DONATE EQUIPMENT & MATERIALS 1.2.6
ARRANGE TECHNICAL TOUR 1.2.4
INFORM OF OPPORTUNITIES & QUALIFICATIONS 1.2.2
1.2
CHANNEL INFORMATION INFORMALLY
CHANNEL BY RELATIVES 1.5.1
CHANNEL BY OTHERS 1.5.2
FURNISH DURING LEISURE-TIME ACTIVITIES 1.5.3
CHANNEL BY GRADUATES 1.5.4
1.5
1.0
F
IDENTIFY INTERESTS OF EMPLOYEE & TRADE ASSNS
PUBLISH MAGAZINES & BROCHURES 10.1
CONDUCT MEETINGS 10.2
PROVIDE APPRENTICE INSTRUCTION 10.3
10.0
PERFORM ON JOB: NON-BUSINESS
TEACH AT JUNIOR COLLEGE OR COLLEGE 14.1
REVIEW NEW BOOK OR MANUSCRIPT 14.2
14.0
PRODUCE RESOURCE MATERIALS


GENERATE OUTSIDE SOURCES
FURNISH REPAIR WORK 15.1
FURNISH NON-GRADUATE 15.2
FURNISH OTHER DISTRICTS 15.3
15.0
PERFORM MILITARY SERVICE 2.0
PERFORM DEGREE-DIRECTED ACTIVITIES 3.0
CONDUCT COMPREHENSIVE VOCATIONAL-TECHNICAL PROGRAM
4.2
STUDENT 4.4
CONDUCT CURRICULUM
CONDUCT COOPERATIVE PHASE (TCHR-CSS) 4.3.1
CONDUCT FIELD TRIPS 4.3.2
CONDUCT COURSES
CLASS 4.33.1
LAB
SHOP 4.3.3.2
REPAIR WORK
FOLLOW-UP GRADUATES ON JOB 4.7
DEMONSTRATION IN SHOP BY GRADUATE 4.11
PROVIDE HUMAN INSTRUCTION
MEMORY
FORGETTING 4.6.1.4
SHORT-TERM 4.6.1.2
LONG-TERM 4.6.1.3
WORKING 4.6.1.1
4.6.1
SUMMER
CRITERION COMPARATOR 4.6.2
DECISION 4.6.3
PRE-ACTION EVALUATION 4.6.4
4.6
IN-SERVICE TRG USING COMPUTER-ASSTD INSTR 4.8
F
ALS & SERVICES
PROVIDE STATE DEPT
FURNISH
4.2


E
CONDUCT CURRICULUM
CONDUCT COOPERATIVE PHASE (WORK-CO-OP) 4.3.1
CONDUCT FIELD TRIPS 4.3.2
CONDUCT COURSES
CLASS 4.3.3.1
LAB 4.3.3.3
SHOP 4.3.3.2
REPAIR WORK 4.3.3.4
4.3.3
4.3
DEVELOP CURRICULUMS (MACRO) 4.2
PERFORM HUMAN ACTIVITY ANALYSES 4.1
9.3
7.1
F
DEMONSTRATION IN SHOP BY GRADUATE 4.11
CTION
TERM
6.1.3
4.6.1
SUMMER
+
Σ
CRITERION COMPARATOR 4.6.2
DECISION 4.6.3
PRE-ACTION EVALUATION 4.6.4
4.6
PROVIDE OCCUPATIONAL GUIDANCE & PLACEMENT 4.5
DEVELOP INSTRUCTIONAL MATERIALS 4.10
PERFORM SCHOOL DISTRICT ADMINISTRATION
EMULATE OTHER PROGRAMS 4.9.2
EVALUATE PROGRAMS OTHER DISTRICTS 4.9.1
EXAMINE SOFTWARE 4.9.3
EXPEND $ 4.9.4
4.9
4.0
OBTAIN & DISBURSE $
OPERATE TAX MACHINE
OBTAIN LOCAL TAX $ 11.2.1
OBTAIN FEDERAL & STATE TAX $ 11.2.2
11.2
EXPEND FOR NON-SCHOOL PURPOSES 11.1
CONDUCT SELF AS CITIZEN
PAY TAXES 13.1
CREATE & APPLY PRESSURE 13.2
13.0
4.2


1.6.2
1.6
1.4.1.3
VACATION 1.4.1.4
PROGRAM 1.4.2
SABBATICAL LEAVE 1.4.1.5
1.4.1
1.4
Ⓕ
PROVIDE MANAGEMENT OPERATING CONTROLS
ESTABLISH OCCUPATIONAL STANDARDS 1.3.2
SUPERVISE (FIRST-LINE) 1.3.3
MANAGE 1.3.1
1.3
PERFORM WORK
PRODUCE (OTHERS) 1.1.2
PRODUCE (GRADUATES) 1.1.1
1.1
PROVIDE PERSONNEL FUNCTION INTERFACE
IDENTIFY COURSE ELEMENTS (TRAINING DIR.) 1.2.5
ESTABLISH FORMAL PROGRAM 1.2.3
EMPLOY GRADUATES 1.2.1
DONATE EQUIPMENT & MATERIALS 1.2.6
ARRANGE TECHNICAL TOUR 1.2.4
INFORM OF OPPORTUNITIES & QUALIFICATIONS 1.2.2
1.2
CHANNEL INFORMATION INFORMALLY
CHANNEL BY RELATIVES 1.5.1
CHANNEL BY OTHERS 1.5.2
FURNISH DURING LEISURE-TIME ACTIVITIES 1.5.3
CHANNEL BY GRADUATES 1.5.4
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IDENTIFY INTERESTS OF EMPLOYEE & TRADE ASSNS
PUBLISH MAGAZINES & BROCHURES 10.1
CONDUCT MEETINGS 10.2
PROVIDE APPRENTICE INSTRUCTION 10.3
10.0
PERFORM ON-JOB: NON-BUSINESS
TEACH AT JUNIOR COLLEGE OR COLLEGE 14.1
REVIEW NEW BOOK OR MANUSCRIPT 14.2
14.0
PERFORM ASSOCIATION SURVEILLANCE
ACQUIRE DATA (TRADE ASSN) 8.1
ACQUIRE DATA (EMPLOYEE ASSN) 8.2
ACQUIRE DATA (PROFESSIONAL SOCIETY) 8.3
8.0
IDENTIFY MACRO CHANGES THROUGH ADVISORY COMMITTEE
ANALYZE BUSINESS & INDUSTRIAL DATA 9.1
PRODUCE POLICY 9.3
4.2
ANALYZE EMPLOYEE DATA 9.2
OPERATE CRAFT COMMITTEE 9.5
OPERATE STATE-LEVEL COMMITTEE 9.6
ANALYZE EDUCATION DATA 9.4
9.0
PRODUCE RESOURCE MATERIALS & SE
VENDOR PUBLISH MANUALS & CATALOGS (INSTRUCTOR) 5.2
VENDOR PUBLISH SOFTWARE (STUDENT) 5.6
MANUFACTURE HARDWARE 5.1
ADVERTISE
MAIL 5.4.1
5.4.2
5.4
VENDO TRAD
VENDOR FURNISH IN-SERVICE TRAINING 5.3
VENDOR PUBLISH SOFTWARE (INSTRUCTOR) 5.5
GOVERNMENT PUBLISH OCCUPATIONAL DATA 5.8
GOVERNMENT WALK-IN INSPECTION (F.A.A.) 5.9
GOV TEST (F.A.A.

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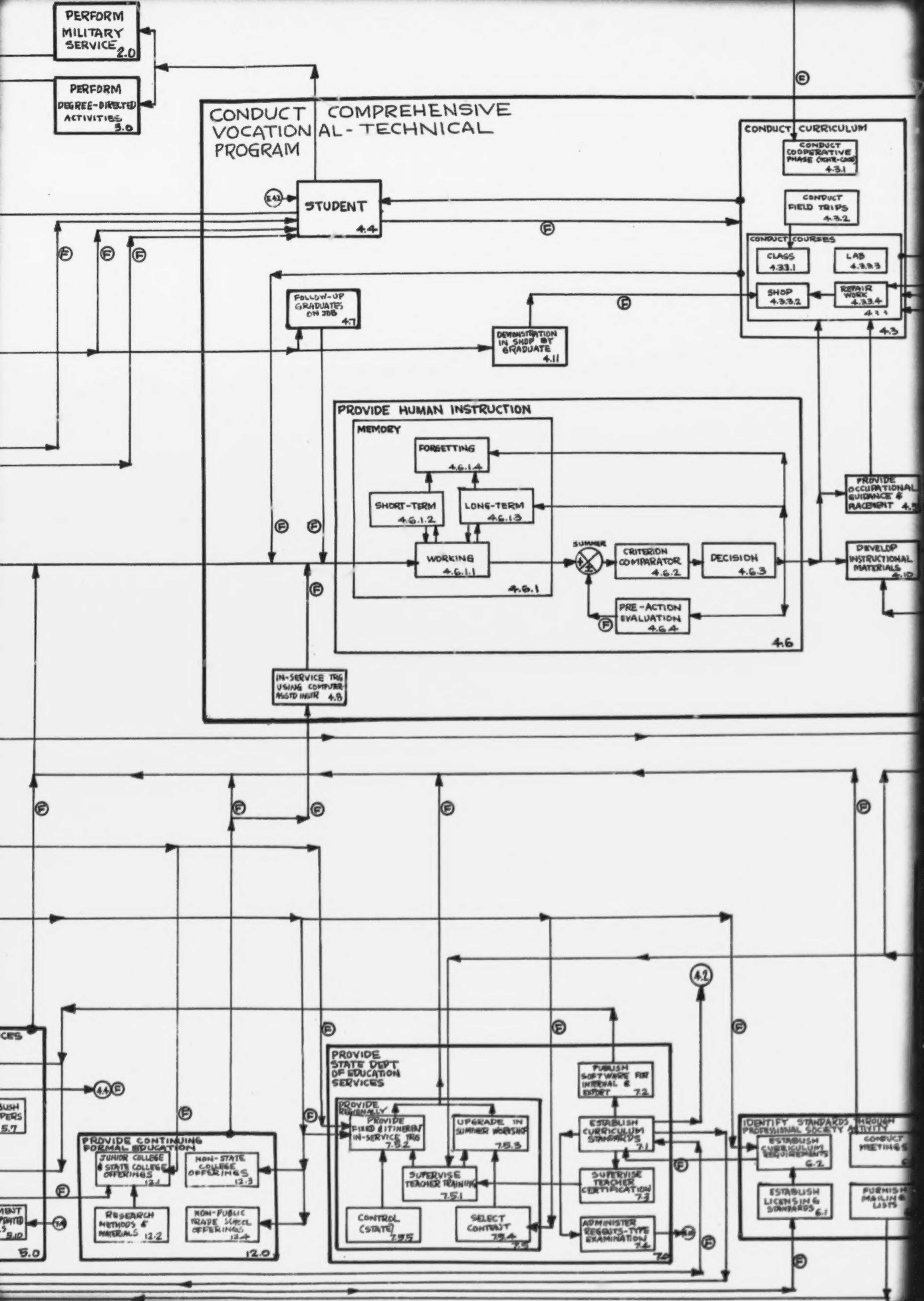
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PERFORM DEGREE-DIRECTED ACTIVITIES 3.0
CONDUCT COMPREHENSIVE VOCATIONAL-TECHNICAL PROGRAM
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STUDENT 4.4
CONDUCT CURRICULUM
CONDUCT COOPERATIVE PHASE (TCHR-COOR) 4.3.1
CONDUCT FIELD TRIPS 4.3.2
CONDUCT COURSES
CLASS 4.33.1
LAB 4.3.3.3
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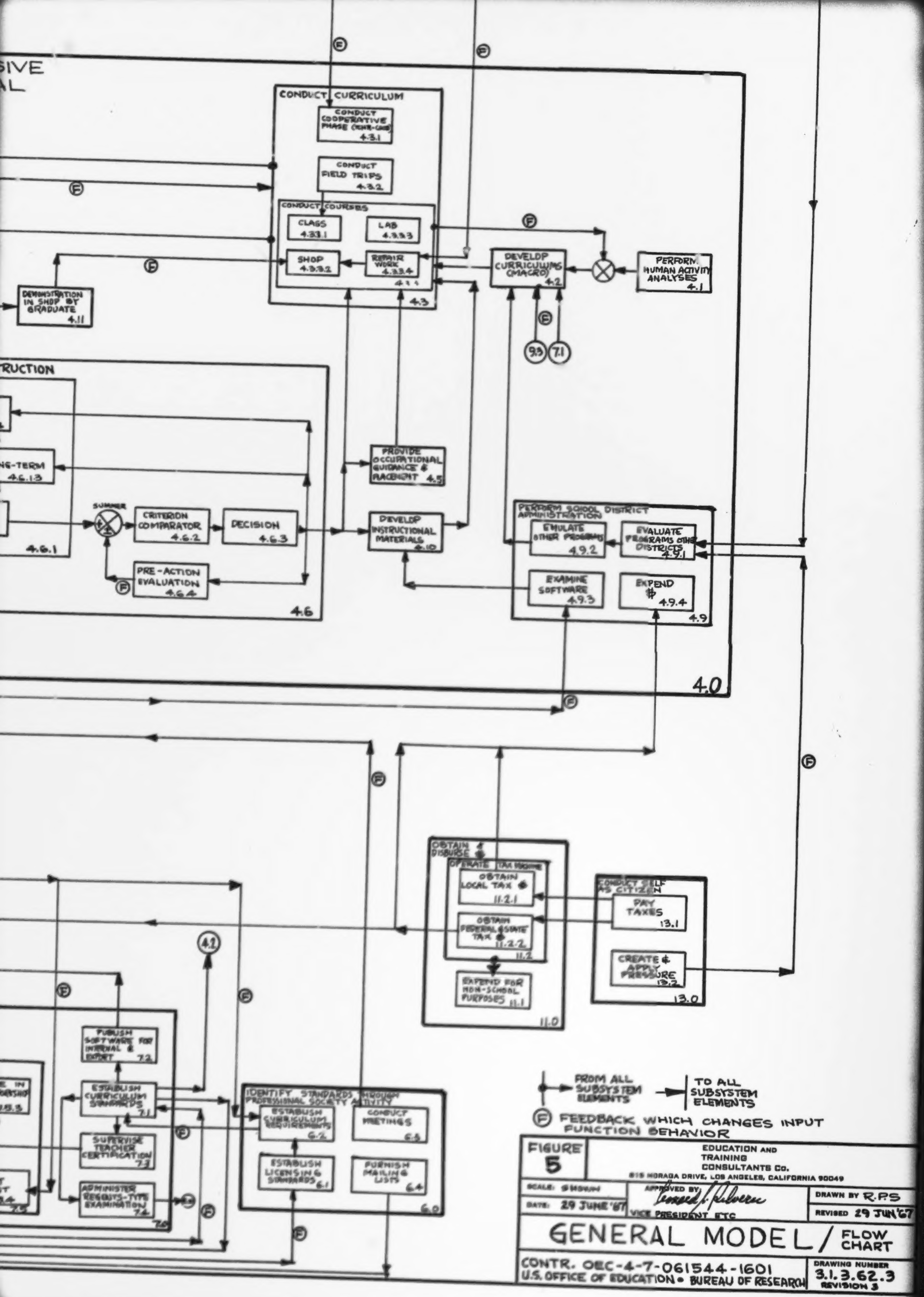
FOLLOW-UP GRADUATES ON JOB 4.7
DEMONSTRATION IN SHOP BY GRADUATE 4.11
PROVIDE HUMAN INSTRUCTION
MEMORY
FORGETTING 4.6.1.4
SHORT-TERM 4.6.1.2
LONG-TERM 4.6.1.3
WORKING 4.6.1.1
4.6.1
SUMMER
+
−
CRITERION COMPARATOR 4.6.2
DECISION 4.6.3
PRE-ACTION EVALUATION 4.6.4
4.6
PROVIDE OCCUPATIONAL GUIDANCE & PLACEMENT 4.5
DEVELOP INSTRUCTIONAL MATERIALS 4.10
IN-SERVICE TRG USING COMPUTER-ASSTD INSTR 4.8
F
CES
BUSH PERS 5.7
4.4 F
MENT PRATED S 5.10
7.4
5.0
PROVIDE CONTINUING FORMAL EDUCATION
JUNIOR COLLEGE & STATE COLLEGE OFFERINGS 12.1
NON-STATE COLLEGE OFFERINGS 12.3
RESEARCH METHODS & MATERIALS 12.2
NON-PUBLIC TRADE SCHOOL OFFERINGS 12.4
12.0
PROVIDE STATE DEPT OF EDUCATION SERVICES
PROVIDE REGIONALLY
PROVIDE FIXED & ITINERANT IN-SERVICE TRG 7.5.2
UPGRADE IN SUMMER WORKSHOP 7.5.3
SUPERVISE TEACHER TRAINING 7.5.1
CONTROL (STATE) 7.5.5
SELECT CONTENT 7.5.4
7.5
PUBLISH SOFTWARE FOR INTERNAL & EXPORT 7.2
ESTABLISH CURRICULUM STANDARDS 7.1
SUPERVISE TEACHER CERTIFICATION 7.3
ADMINISTER REGENTS-TYPE EXAMINATION 7.4
7.0
4.2
IDENTIFY STANDARDS THROUGH PROFESSIONAL SOCIETY ACTIVITY
ESTABLISH CURRICULUM REQUIREMENTS 6.2
CONDUCT MEETINGS
ESTABLISH LICENSING STANDARDS 6.1
FURNISH MAILING LISTS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CONDUCT COOPERATIVE PHASE (WORK-LINK) 4.3.1
CONDUCT FIELD TRIPS 4.3.2
CONDUCT COURSES
CLASS 4.3.3.1
LAB 4.3.3.3
SHOP 4.3.3.2
REPAIR WORK 4.3.3.4
4.3.3
4.3
DEVELOP CURRICULUMS (MACRO) 4.2
PERFORM HUMAN ACTIVITY ANALYSES 4.1
9.3
7.1
DEMONSTRATION IN SHOP BY GRADUATE 4.11
RUCTION
NG-TERM 4.6.1.3
4.6.1
SUMMER
CRITERION COMPARATOR 4.6.2
DECISION 4.6.3
PRE-ACTION EVALUATION 4.6.4
4.6
PROVIDE OCCUPATIONAL GUIDANCE & PLACEMENT 4.5
DEVELOP INSTRUCTIONAL MATERIALS 4.10
PERFORM SCHOOL DISTRICT ADMINISTRATION
EMULATE OTHER PROGRAMS 4.9.2
EVALUATE PROGRAMS OTHER DISTRICTS 4.9.1
EXAMINE SOFTWARE 4.9.3
EXPEND $ 4.9.4
4.9
4.0
OBTAIN & DISBURSE $
OPERATE TAX MACHINE
OBTAIN LOCAL TAX $ 11.2.1
OBTAIN FEDERAL & STATE TAX $ 11.2.2
11.2
EXPEND FOR NON-SCHOOL PURPOSES 11.1
11.0
CONDUCT SELF AS CITIZEN
PAY TAXES 13.1
CREATE & APPLY PRESSURE 13.2
13.0
4.2
PUBLISH SOFTWARE FOR INTERNAL & EXPORT 7.2
ESTABLISH CURRICULUM STANDARDS 7.1
SUPERVISE TEACHER CERTIFICATION 7.3
ADMINISTER REGENTS-TYPE EXAMINATION 7.4
7.0
E IN RSHIP
15.3
7.5
IDENTIFY STANDARDS THROUGH PROFESSIONAL SOCIETY ACTIVITY
ESTABLISH CURRICULUM REQUIREMENTS 6.2
CONDUCT MEETINGS 6.3
ESTABLISH LICENSING STANDARDS 6.1
FURNISH MAILING LISTS 6.4
6.0
F
FROM ALL SUBSYSTEM ELEMENTS
TO ALL SUBSYSTEM ELEMENTS
F FEEDBACK WHICH CHANGES INPUT FUNCTION BEHAVIOR

FIGURE 5

EDUCATION AND
TRAINING
CONSULTANTS Co.
815 MORAGA DRIVE, LOS ANGELES, CALIFORNIA 90049

SCALE: SHOWN
DATE: 29 JUNE '67
APPROVED BY: Leonard J. Silvern
VICE PRESIDENT ETC
DRAWN BY R.P.S
REVISED 29 JUN '67

GENERAL MODEL / FLOW CHART

CONTR. OEC-4-7-061544-1601
U.S. OFFICE OF EDUCATION • BUREAU OF RESEARCH
DRAWING NUMBER 3.1.3.62.3
REVISION 3

This model is important since nearly all the evidence gathered in this project points to the instructor as the primary decision-making function.

In Figure 5, we see the model synthesized as a result of all the critical evidence gathered in this project. This figure is in large flowchart model form and is enclosed with this report.

Because Figure 5 is delineated to the 4th level of detail, Figure 6 presents a 1st level or system model which will be used now to introduce Figure 5.

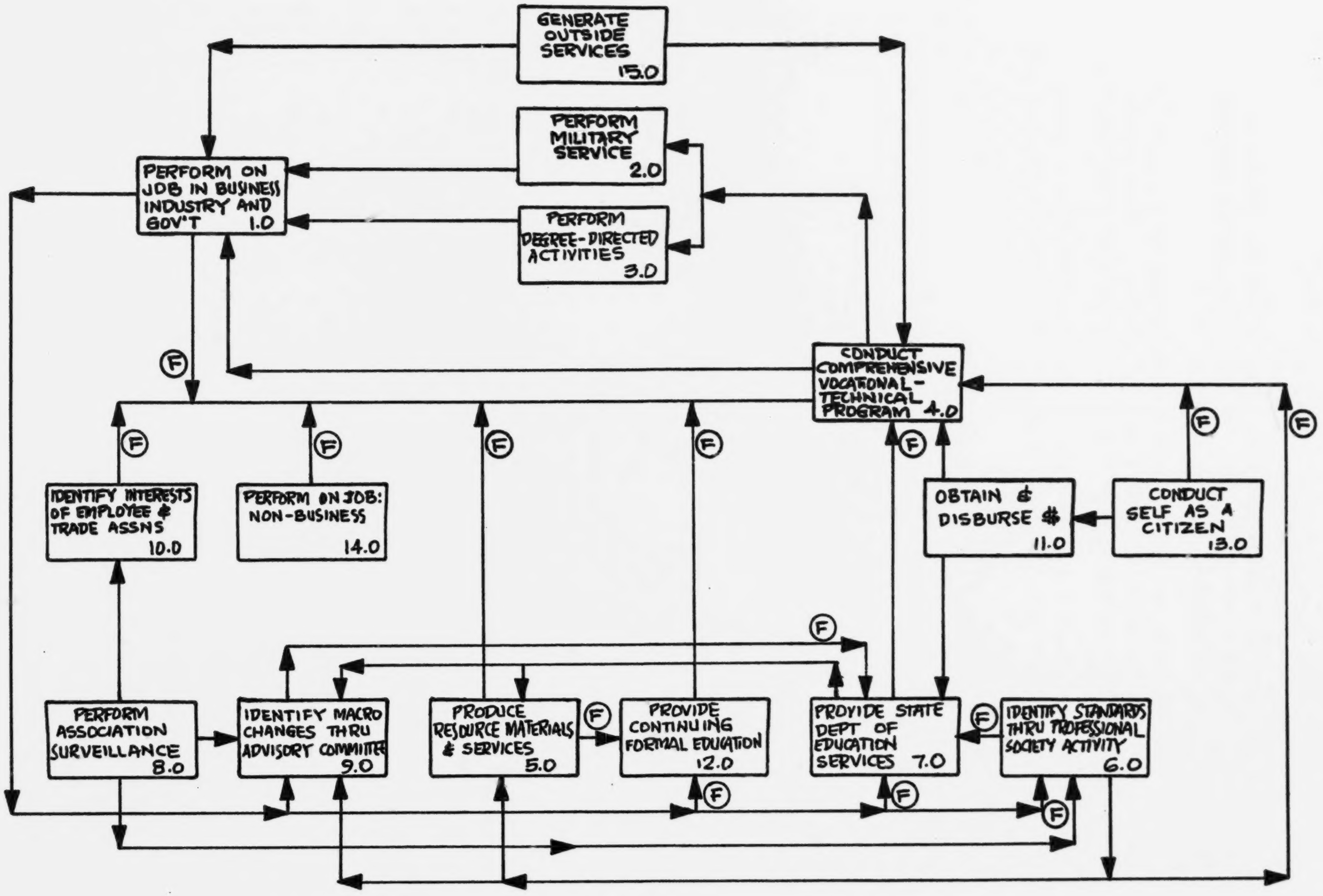
GENERATE OUTSIDE SERVICES 15.0
PERFORM MILITARY SERVICE 2.0
PERFORM ON JOB IN BUSINESS INDUSTRY AND GOV'T 1.0
PERFORM DEGREE-DIRECTED ACTIVITIES 3.0
CONDUCT COMPREHENSIVE VOCATIONAL-TECHNICAL PROGRAM 4.0
F
IDENTIFY INTERESTS OF EMPLOYEE & TRADE ASSNS 10.0
PERFORM ON JOB: NON-BUSINESS 14.0
OBTAIN & DISBURSE $ 11.0
CONDUCT SELF AS A CITIZEN 13.0
PERFORM ASSOCIATION SURVEILLANCE 8.0
IDENTIFY MACRO CHANGES THRU ADVISORY COMMITTEE 9.0
PRODUCE RESOURCE MATERIALS & SERVICES 5.0
PROVIDE CONTINUING FORMAL EDUCATION 12.0
PROVIDE STATE DEPT OF EDUCATION SERVICES 7.0
IDENTIFY STANDARDS THRU PROFESSIONAL SOCIETY ACTIVITY 6.0

FIGURE 6

C. RESULTS

1. Model Analysis - First Level of Detail

Both student and teacher are subsystems within (4.0). Students leave a secondary school by graduation or non-completion and enter employment (1.0), enter an institution of higher education (3.0) or perform military service (2.0).

At some point in time after leaving secondary school (4.0) they will also leave the military (2.0) and college (3.0) subsystems for employment in business, industry and government (1.0). It is virtually impossible for a person leaving (4.0) and entering (1.0), (2.0), or (3.0) to return to the same (4.0) environment. Thus, any inputs to (4.0) from outside, due to this time continuum, will affect younger students and not the original students whose paths are being traced. However, while the flow is discrete at the atomic level, it may be viewed as continuous at the molecular level. Certainly, the occupational teacher performs as a continuous function and it is this function within (4.0) being examined in Figure 6. The conventional electrical signal analog applies exactly.

(4.0) has more signal inputs than any other subsystem, 10 to be precise. While there are many feedback signals, (4.0) has 8 major feedback inputs. This is the natural outgrowth of any study designed to critically examine a particular subsystem. The number of signal paths may be less significant than the frequency with which a signal is input, the intensity of a signal, the effect of a signal on the behavior of a subsystem, etc.

Subsystem (10.0) produces feedback to (4.0) generally in the form of information obtained from employee and trade association magazines, brochures, meetings, etc. Such data is supposed to add to an instructor's knowledge bank and thereby modify his behavior. The information in (10.0) is partly obtained from various surveillance or "early warning" sensors operated by associations and societies (8.0).

The same surveillance data (8.0) also operates on (9.0) and is translated into recommendations and policies by advisory bodies at various levels. At the macro level, information is transmitted to a State Department of Education (7.0). At a lower macro level, it is transmitted to the school district, and at an even lower macro level to the occupational teacher in a particular secondary school of the same school district (4.0). (9.0) obtains information from (7.0) and both information and manpower (members) from (1.0).

Professional societies (6.0) also operate a surveillance function (8.0) and use this feedback to stabilize their behaviors. This is accomplished through meetings attended by teachers (4.0), recommendations for licensing (or non-licensing) and curriculum requirements transmitted to (7.0).

A State Department of Education (7.0) uses (6.0) and (9.0) information as feedback to modify its behavior but one signal input in particular, from (11.0), namely federal and state tax $, has a sobering influence. Also, at the regional level where programs are operated to reach an occupational teacher directly (4.0), feedback from real-life is packaged in the form of experienced managers and supervisors from (1.0) who instruct and may have a role in selecting occupational content for teacher training programs in (7.0).

It is the tax-paying citizen (13.0) who furnishes the $ to (11.0) which go to (7.0) at the State level and to a particular school or school tax district (4.0) at the local level. (13.0) acting as a non-parent, can create and apply pressure to the management of a district in various ways (4.0). (13.0) rarely acts as a parent in this role.

Occupational instructors are looking more and more to state colleges, community colleges, junior colleges, and even non-public trade schools (12.0) to obtain information used as feedback to correct errors in their behavior (4.0). These institutions face the same problem of presenting updated information, so error-correcting feedback enters (12.0) in the form of experienced managers, supervisors and technical employees from (1.0). Because of greater academic freedom in higher education, feedback also enters from (5.0) in the form of vendors who furnish "in-service" training which invariably focuses upon the products being produced in (5.0). To some small extent, internally generated research and development in occupational materials and methods may reach a classroom in (12.0) and thus reach (4.0).

Occupational instructors rely upon certain resources (5.0) and the information generated to update their content and, as feedback from real-life, alter their behavior. There are minor signals to (5.0) from (6.0) which consists mainly of the provisioning of mailing lists for vendor advertising purposes. Major signals to (5.0) from (6.0) consists of furnishing state-administered tests used for licensing or other purposes.

In terms of national practice, subsystem (14.0) is undoubtedly the least significant. It consists of job experience obtained by an occupational teacher instructing at a junior college or college and reviewing books and manuscripts for publishers. The most significant is (1.0) which describes job environments in business, industry and government. Students from secondary school enter (1.0) and spend 25% of their working lives there, over a time period of 45 years (20 to 65). Error-correcting feedback from (1.0) to (4.0) may be in a variety of forms: supervisory instruction to students engaged in cooperative, work-study programs, supervisory instruction to teachers employed either in a special program or randomly, information channelled through social or leisure-time activities from employees to teachers, information transmitted by personnel departments to teachers, and so forth.

This is a cybernetic model. It deals exclusively in information and information is considered as the central concept in the entire field of cybernetics (60). It deals with information processing, the action resulting from changes in input. It is a crude model of what is...rather than what should be.

A synthesis of many "cybernetics" definitions into one, by Klír and Valach, is quite useful (60):

> "Cybernetics is a science dealing, on the one hand, with the study of relatively closed systems from the viewpoint of their interchange of information with their environment, on the other hand with the study of the structures of these systems from the viewpoint of the information interchange between their elements."

2. Model Analysis - Closed Loops Using Feedback

Reference is made now to Figure 5; the reader will find it useful to re-establish his system-level frame of reference by continual examination of Figure 6 together with Figure 5 to avoid becoming lost in the graphic details. There are at least four characteristics of each information loop:

Criteria for frequency (f):

high = continuous information flow with virtually no breaks when examined on a semester unit basis

moderate=discrete information flow with regular and irregular breaks but viewed as continuous when examined on a 4-semester (2 year) unit basis

low = discrete information flow with many regular and irregular breaks and viewed as discontinuous, random and sporadic when examined on a 4-semester (2 year) unit basis

zero = no information flow when examined on a 4-semester (2 year) unit basis

Criteria for *entropy* (H):

high = total disorder and disorganization of the information and signal path

moderate = partial disorder and order of the information and signal path

zero = complete order and organization of the information and signal path

Criteria for *figure of merit* (M):

high = 100% of information can be used with little alteration at the unit, sub-unit, lesson, teaching point, or step levels (see Figure 2)

moderate = 50% of information can be used with little alteration, *or*, 100% of information can be used with major alteration, *or*, some combination of these, at the unit, sub-unit, lesson, teaching point, or step levels (see Figure 2)

zero = 100% of information cannot be used with any alteration, at the unit, sub-unit, lesson, teaching point, or step levels (see Figure 2)

Criteria for *reliance* (R):

high = information completely free of noise, distortion, data transmission errors (bits); can be considered 100% reliable

moderate = information has picked up random noise, has been phase-changed or distorted, or has dropped or picked up bits in transmission; can be considered between 30-80% reliable

zero = information received is totally different from that originally transmitted

Criteria for *recency* (t):

high = information when received is less than 2 semesters (1 year) old, measured from time of initial transmission by originating source

moderate = information when received is between 2 and 6 semesters (1-3 years) old, measured from time of initial transmission by originating source low = information when received is between 6 and 10 semesters (3-5 years) old, measured from time of initial transmission by originating source

zero = information when received is greater than 11 semesters (5½ years) old, measured from time of initial transmission by originating source

While these characteristics are adequate for this report, additional work to identify and quantify is recommended.

a. employee-trade association loop

(1) path: 8.1+8.2→10.0→4.6.1.1
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: high
(6) recency: high
(7) evaluation: rarely used by occupational teachers; information often not directly applicable in instruction but may be useful in guidance suggests improving this loop.

b. non-business loop

(1) path: 14.0→4.6.1.1
(2) frequency: zero
(3) entropy: zero
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: moderate
(7) evaluation: an obscure activity rarely used by occupational teachers; does not lend itself to expansion for a large number of occupational teachers; suggests ignoring this loop.

c. craft committee loop

(1) path: 1.3.3+1.3.1→9.1→9.3→9.5→4.6.1.1
(2) frequency: low
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: a highly worthwhile activity which is rarely practiced at the teacher level (see Burt; "Industry Participation in

Local Public School Vocational and Technical Education; ref. 63); an essential path for vocational-technical teachers in comprehensive secondary schools who might not have alternate feedback inputs; suggests improving this loop.

d. advisory committee loop

(1) path: 1.3.3+1.3.1 → 9.1 → 9.3 → 4.2
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: zero
(5) reliance: high
(6) recency: high
(7) evaluation: most often operating upon a director of vocational education of a school district, a principal or a chairman; inputs do not reach the teacher; inputs are at the macro level useful only for general planning; suggests redesigning or otherwise improving this loop.

e. state-level committee loops

(1) path: 1.3.3+1.3.1 → 9.1+9.2 → 9.6 → 7.1 → 7.2 → 5.6+5.5 →

$$4.6.1.1 \leftarrow \begin{Bmatrix} 5.4.2 \\ 5.7 \end{Bmatrix} \leftarrow 5.4 \leftarrow$$

(2) frequency: low
(3) entropy: zero
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: moderate
(7) evaluation: software produced by state agencies, often through state universities, reaches the teacher; however, it may be prepared by curriculum specialists who have been away from the occupation for many years and the material may contain obsolete data; the strong path is from 7.2 while weaker paths are 7.1 → 7.2 and 9.6 → 7.1; suggests improving this loop and redesigning inputs to 7.2 from other sources.

(1) path: 1.3.3+1.3.1 → 9.1+9.2 → 9.6 → 7.1 → 7.3 → 7.5.1 →

$$4.6.1.1 \leftarrow \begin{Bmatrix} 7.5.2 \\ 7.5.3 \end{Bmatrix} \leftarrow$$

(2) frequency: zero
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: teacher-training based on advisory committee inputs occurs only at begining of teacher probation period and is rarely influenced by committee; suggests improving this loop.

(1) path; 1.3.3+1.3.1→9.1+9.2→9.6→7.1→4.2
(2) frequency: low
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: advisory committee inputs through state agency to district are at macro level and almost never reach teacher; path for the teacher who is beyond probation period is valueless.

f. manager-supervisor direct loops

(1) path: 1.3.3+1.3.1→12.3+12.4→4.6.1.1
(2) frequency: moderate
(3) entropy: zero
(4) figure of merit: moderate
(5) reliance: high
(6) recency: high
(7) evaluation: extremely useful loop but limited to occupational teachers who are within commuting distance of institution or who can use summer vacation periods; suggests expanding this loop.

(1) path: 1.3.3+1.3.1→12.3+12.4→4.8→4.6.1.1
(2) frequency: moderate
(3) entropy: zero
(4) figure of merit: high
(5) reliance: high
(6) recency: high
(7) evaluation: a very useful loop but practiced in only a few States; instructors in 7.5.3 are usually the same persons from 1.3.3+1.3.1 who function in 7.5.4; suggests expanding this loop.

g. manager on job loops

(1) path: 1.3.1→1.2.5+1.2.6+1.2.2→4.6.1.1
(2) frequency: zero
(3) entropy: high
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: moderate
(7) evaluation: managers transmit through personnel department functions; often, the personnel function acts as a buffer or filter and this affects the information flow; suggests redesigning, improving and expanding this loop.

(1) path: 1.3.1→1.2.4→4.4→4.3.2→4.6.1.1
(2) frequency: zero
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: managers transmit through touring students who later interact with their teachers; while a theoretically exciting notion, it is completely disordered and uncontrollable by most occupational teachers; suggests expanding the techniques without hope for any major decrease in entropy and concentrating on more promising paths.

(1) path: 1.3.1→1.2.3→1.4.2→4.6.1.1
(2) frequency: moderate
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: high
(6) recency: high
(7) evaluation: formal programs are extremely rare; those programs which operate are believed to be highly effective which suggests expanding formal programming.

(1) path: 1.3.1→1.2.1→1.1.1→1.5.4→4.11→4.3.3.2→
4.6.1.1←

(2) frequency: low
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy

(7) evaluation: inviting a graduate to return to a school shop or laboratory and demonstrate a process or explain a method is a rare event; even rarer is the probability that the occupational teacher would acquire an input from a manager which would modify his behavior; although only a small input should be expected from the technique, it does hold promise and suggests an expansion.

h. supervisor on job loops

(1) path: 1.3.3→4.3.1→4.6.1.1
(2) frequency: moderate
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: high
(7) evaluation: supervision during the cooperative phase feeds back information by face-to-face communication with the teacher-coordinator; this is aside from other information fed back through the student; it is more effective than relying on resource materials but much less effective than the teacher working under the same supervisor as an employee.

(1) path: 1.3.3→1.1.1→1.5.4→4.11→4.3.3.2→4.6.1.1
(2) frequency: low
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: this is essentially the same as the 1.3.1→1.2.1→1.1.1→etc. loop for the manager and the same evaluation is warranted.

(1) path: 1.3.3→1.1.2→1.4.1→4.6.1.1
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: high
(5) reliance: high
(6) recency: high
(7) evaluation: the acquisition of information through employment, even on a random basis, so a supervisor's knowledge is transmitted directly to an occupational instructor is deemed to be the most successful feedback short of full-time, formal pro-

gram employment; this loop is one which should be *expanded*.

(1) *path*: 1.3.3→1.1.2→1.4.2→4.6.1.1
(2) *frequency*: moderate
(3) *entropy*: moderate
(4) *figure of merit*: moderate
(5) *reliance*: high
(6) *recency*: high
(7) *evaluation*: this is essentially the same as the 1.3.1→1.2.3→1.4.2→4.6.1.1 loop for the manager and the same evaluation is warranted.

i. *manager off job loop*

(1) *path*: 1.3.1→1.5.3→4.6.1.1
(2) *frequency*: low
(3) *entropy*: moderate
(4) *figure of merit*: moderate
(5) *reliance*: moderate
(6) *recency*: high
(7) *evaluation*: manager-teacher interaction as a leisure time activity appears to be a major source of feedback for occupational information; suggests *expanding* this loop.

j. *employee on job loop*

(1) *path*: $1.1.2 \rightarrow \left\{\begin{matrix} 1.4.1 \\ 1.4.2 \end{matrix}\right\} \rightarrow 4.6.1.1$
(2) *frequency*: low
(3) *entropy*: moderate
(4) *figure of merit*: high
(5) *reliance*: moderate
(6) *recency*: high
(7) *evaluation*: information acquired on the job through employment, from other employees, is considered highly effective; suggests *expanding* the loop.

k. *employee off job loop*

(1) *path*: $1.1.2 \rightarrow \left\{\begin{matrix} 1.5.1 \\ 1.5.2 \end{matrix}\right\} \rightarrow 1.5.3 \rightarrow 4.6.1.1$
(2) *frequency*: low
(3) *entropy*: moderate
(4) *figure of merit*: moderate
(5) *reliance*: moderate
(6) *recency*: high

(7) *evaluation*: information channelled to an occupational teacher from employees who are relatives, friends, or acquaintences, as a leisure time activity, appears to be a major source of feedback for occupational information; suggests *expanding* this loop.

l. *employee direct loops*

(1) *path*: 1.1.2 → 12.1 → 4.6.1.1
(2) *frequency*: moderate
(3) *entropy*: zero
(4) *figure of merit*: moderate
(5) *reliance*: high
(6) *recency*: high
(7) *evaluation*: employee-teacher relationship where the employee becomes the teacher and the teacher becomes the student; occurs in extension courses or where an adjunct faculty is authorized; high value suggests *expanding* this loop.

(1) *path*: 1.1.2 → 7.5.2 → 4.6.1.1
(2) *frequency*: low
(3) *entropy*: zero
(4) *figure of merit*: moderate
(5) *reliance*: moderate
(6) *recency*: moderate
(7) *evaluation*: although an employee instructs, normally these are *methods* courses in which content is incidental; also, once the probational teacher is certificated, the instruction has ended; suggests *improving* and *expanding* this loop.

m. *special businesses loop*

(1) *path*: $\left\{\begin{matrix}1.6.1\\1.6.2\end{matrix}\right\}$ → 1.4.1 → 4.6.1.1
(2) *frequency*: low
(3) *entropy*: high
(4) *figure of merit*: see entropy
(5) *reliance*: see entropy
(6) *recency*: see entropy
(7) *evaluation*: because consulting and family businesses are limited to only certain types of occupations, employment and the acquisition of information is practiced on a very small scale; there is only a limited gain which suggests *ignoring* this loop.

n. resource materials loops

(1) path: $5.1 \rightarrow \left\{\begin{matrix} 5.4.1 \\ 5.4.2+5.7 \end{matrix}\right\} \rightarrow 4.6.1.1$
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: high
(6) recency: high
(7) evaluation: occupational instructors rely on direct mail and journal advertising of new hardware products to obtain information; suggests improving this loop.

(1) path: 5.1 → 5.2 → 4.6.1.1
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: high
(5) reliance: high
(6) recency: moderate
(7) evaluation: occupational instructors rely on vendor's manuals and catalogs to obtain new hardware product information; instructor initiates inquiry; suggests improving and expanding this loop.

(1) path: $5.1 \rightarrow 5.2 \rightarrow \left\{\begin{matrix} 5.4.1 \\ 5.4.2+5.7 \end{matrix}\right\} \rightarrow 4.6.1.1$
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: high
(5) reliance: high
(6) recency: moderate
(7) evaluation: essentially same as 5.1 → 5.2 → 4.6.1.1 with exception that advertising results in inquiry; suggests improving and expanding this loop.

(1) path: 5.1 → 5.3 → 12.1 → 4.6.1.1
(2) frequency: low
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: vendor presentation of training program as part of regular college offering is both erratic and excessively product-centered; suggests either redesigning or abandoning this loop.

(1) path: $5.1 \rightarrow 5.3 \rightarrow 4.6.1.1$
(2) frequency: moderate
(3) entropy: zero
(4) figure of merit: high
(5) reliance: high
(6) recency: high
(7) evaluation: vendor presentation of training program directly to occupational teacher is considered extremely worthwhile; suggests expanding this loop.

(1) path: $5.6 \rightarrow \left\{ \begin{matrix} 5.4.1 \\ 5.4.2+5.7 \end{matrix} \right\} \rightarrow 4.6.1.1$
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: moderate
(7) evaluation: occupational instructors rely on direct mail and journal advertising of new student software products to obtain information; suggests improving this loop.

(1) path: $5.6 \rightarrow 4.6.1.1$
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: moderate
(7) evaluation: essentially same as $5.6 \rightarrow \left\{ \begin{matrix} 5.4.1 \\ 5.4.2+5.7 \end{matrix} \right\} \rightarrow 4.6.1.1$ with exception that instructor initiates inquiry.

(1) path: $5.5 \rightarrow \left\{ \begin{matrix} 5.4.1 \\ 5.4.2+5.7 \end{matrix} \right\} \rightarrow 4.6.1.1$
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: high
(7) evaluation: occupational instructors rely on direct mail and journal advertising of new instructor software products to obtain information; suggests improving this loop.

(1) path: $5.5 \rightarrow 4.6.1.1$
(2) frequency: low
(3) entropy: moderate

(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: high
(7) evaluation: essentially same as $5.5 \rightarrow \left\{ \begin{matrix} 5.4.1 \\ 5.4.2+5.7 \end{matrix} \right\} \rightarrow 4.6.1.1$ with exception that instructor initiates inquiry.

(1) path: 5.8 → 4.6.1.1
(2) frequency: low
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: information flow of government-generated occupational data is constricted; suggests expanding this loop.

(1) path: 5.9 → 4.6.1.1
(2) frequency: high
(3) entropy: zero
(4) figure of merit: high
(5) reliance: high
(6) recency: high
(7) evaluation: in schools where aeronautics is instructed, information resulting from a Federal Aviation Agency inspection constitutes instant feedback; in that subject area, suggests no change in the loop.

(1) path: 5.10 → 4.6.1.1
(2) frequency: low
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: information flow of government-generated tests and updated manuals, except in aeronautics, is constricted; suggests expanding this loop.

o. university research - university course loop

(1) path: 12.2 → 12.1 → 4.6.1.1
(2) frequency: zero
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy

(7) *evaluation*: research on occupational methods and materials is almost *never* conducted in departments or schools of education of an institution; such research may be conducted in other departments of the same institution but there is rarely any transmission of this research into the education offering; research may not be transmitted to a course offered by the same department conducting the research; suggests *improving* and *expanding* this loop.

p. *state department of education loops*

(1) *path*: 7.5.5 → 7.5.2 → 4.6.1.1
(2) *frequency*: high
(3) *entropy*: zero
(4) *figure of merit*: moderate
(5) *reliance*: moderate
(6) *recency*: low
(7) *evaluation*: because the state-level personnel are somewhat removed from real-life, except in regional offices, information ages and projects never reach the *teacher*; suggests further *study* of this loop.

(1) *path*: 7.5.4 → 7.5.3 → 4.6.1.1
(2) *frequency*: moderate
(3) *entropy*: zero
(4) *figure of merit*: high
(5) *reliance*: high
(6) *recency*: high
(7) *evaluation*: if the input to 7.5.4 is actually (1.3.1+1.3.3) there is a strong possibility at the regional level that the institute will have the ratings shown; if there is no 1.3.1 or 1.3.3 input to 7.5.4, entropy would increase greatly; suggests *expanding* the loop with (1.3.1+1.3.3) inputs.

q. *professional society loops*

(1) *path*: $8.3 \rightarrow 6.1 \rightarrow 6.2 \rightarrow 7.1 \rightarrow \left\{\begin{matrix} 7.2 \\ 7.3 \\ 7.4 \end{matrix}\right\} \rightarrow \ldots 4.6.1.1$
(2) *frequency*: zero
(3) *entropy*: high
(4) *figure of merit*: see entropy
(5) *reliance*: see entropy

(6) recency: see entropy
(7) evaluation: loop is so long, information probably never reaches occupational instructor directly; suggests further study of the loop.

(1) path: $\left\{\begin{matrix}1.3.3\\1.3.1\end{matrix}\right\} \rightarrow 6.2 \rightarrow 7.1 \rightarrow \left\{\begin{matrix}7.2\\7.3\\7.4\end{matrix}\right\} \rightarrow \ldots 4.6.1.1$
(2) frequency: zero
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: same evaluation as previous path.

(1) path: 6.4→5.4.1→4.6.1.1
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: moderate
(7) evaluation: a society mailing list includes only a small percentage of all occupational teachers in a particular occupation; suggest improving and expanding this loop.

(1) path: 6.3→4.6.1.1
(2) frequency: moderate
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: high
(7) evaluation: meetings are a source of occupational trends and content change; suggest expanding this loop.

r. school district administration loops

(1) path: 5.0→4.9.3→4.10→4.3.3→4.6.1.1
(2) frequency: low
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: moderate
(7) evaluation: tends to filter out and acts as buffer between source and occupational instructor; suggests eliminating this loop.

(1) path: 15.3 → 4.9.1 → 4.9.2 → 4.2 → 4.3.3 → 4.6.1.1
(2) frequency: zero
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: practices of other districts may be malpractices or inefficient; decisions usually made to emulate at district level and occupational instructors may receive final decision rather than alternatives; suggests further study of this loop.

(1) path: $4.2 \rightarrow 4.3.3 \rightarrow \otimes \rightarrow 4.2$

(2) frequency: zero
(3) entropy: moderate
(4) figure of merit: moderate
(5) reliance: moderate
(6) recency: zero
(7) evaluation: macro-level curriculum development is not widely practiced; district size determines feedback role of occupational instructor, if any; suggests further study of this internal loop.

s. graduate follow-up loop

(1) path: 1.1.1 → 1.5.4 → 4.7 → 4.6.1.1
(2) frequency: zero
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: graduate follow-up with the objective of curriculum content improvement is rarely practiced; suggests redesigning and expanding this loop.

t. citizen loop.

(1) path $13.2 \rightarrow 4.9.1 \rightarrow 4.9.2 \left\{\begin{matrix}4.2\\4.10\end{matrix}\right\} \rightarrow 4.3.3 \rightarrow 4.6.1.1$

(2) frequency: zero
(3) entropy: high
(4) figure of merit: see entropy
(5) reliance: see entropy
(6) recency: see entropy
(7) evaluation: citizen input is buffered by administration and rarely reaches occupational teacher; suggests further study of this loop.

u. outside source loop

(1) path: 15.1→4.3.3.4→4.3.3.2→4.6.1.1
(2) frequency: high
(3) entropy: zero
(4) figure of merit: high
(5) reliance: high
(6) recency: high
(7) evaluation: where practiced, shop repair work brought in from real-life is an excellent source of information for the occupational teacher; suggests expanding this loop.

D. DISCUSSION

This study has produced a model in which 49 feedback signal paths to the occupational teacher have been identified and evaluated in terms of frequency (f), entropy (H), figure of merit (M), reliance (R), and recency (t).

In gross terms, the performance (P) of the occupational teacher may be expressed as:

$$P = f(f,H,M,R,t)$$

Thus, the objectives (a) to (f) inclusive, on page 7, have been achieved.

Clearly (P) refers only to that part of an occupational instructor's performance which deals with acquiring feedback inputs which can be used intrapersonally to modify his information on subject *content*. (P) does not include all of an instructor's performance.

The five *characteristics* (f,H,M,R,t) represent a first pass at identification. They may require alteration, elimination and/or addition. The crude *scales*, high-moderate-low-zero, and the *definition* of these scales, can probably be refined.

The signal paths, totalling 49, will require a more precise identification. Some may be discarded, others identified and combined.

It was also outside the scope of this study to examine various combinations of signal paths and to determine the effects on an occupational teacher.

Interviews, as described earlier, formed the basis for much of the information synthesized into the flowchart model. If a much larger sample were used, it is possible that the model might be altered by 10%, and the evaluations by a greater percentage.

It becomes clear, in working through the model and the evaluations, that certain feedback signal paths are more critical than others. *If occupational curriculums are to be updated, the more critical signal paths must be redesigned, improved and expanded.*

It is also obvious that, unless those interviewed identified the signal paths or unless the project staff had experienced such paths, a path *would not* be shown. This means that the study was *not* designed to identify *inventions*...to create unique paths...to synthesize non-existing paths.

Striner states: "... the rate of change has increased and that, apparently, institutions have not kept pace with technological change... our information system is incapable of dealing with these changes... the schools must see themselves as part of a system in which they relate to other institutions. I am referring here to the development of a much closer relationship between schools and the industrial and business communities..." (64).

A revised and updated guide on an industrial education woodworking program published in 1966 included a bibliography (65). A frequency distribution of publication dates appears in Figure 7.

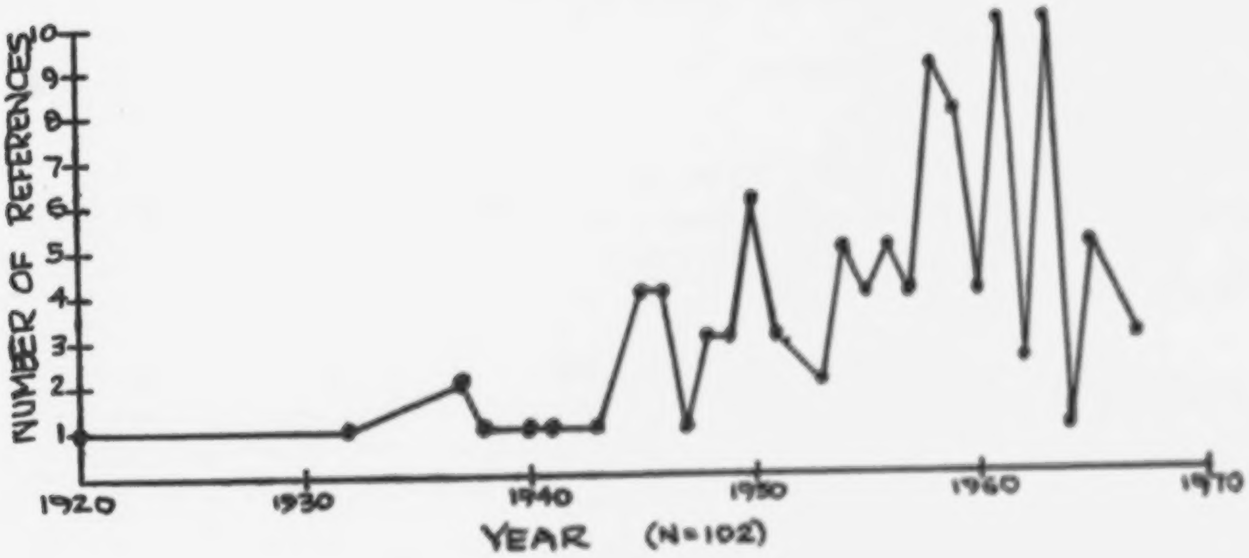

FIGURE 7

One is struck by the large number of references which were published more than 10 years before the guide date of publication. Of 127, 25 had no date of publication listed in the bibliography. Of 102 which were so identified, 48 (47%) were at least 10 years old; 32 (31%) were at least 15 years old.

The model developed in this study should be able to quantitatively describe recency (t), for example, as a function of instructor performance (P). However, the study did not extend to a quantified model.

E. CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

The model, synthesized in Figure 5, has these characteristics:

a. it is a high-fidelity analog of real-life,

b. it is a cybernetic model, showing interaction with a real-life environment,

c. it is closed-loop with a large number of feedback signal paths, extrinsic and intrinsic to the school or school district,

d. it is a general model of secondary schools and of occupational teachers in those schools,

e. it has closed-loop feedback paths each of which is identifiable in terms of up to five characteristics,

f. it appears possible to measure the value of each feedback loop in crude units,

g. instructor performance (P) dealing with the inputting of updated information is a function of (f,H,M,R,t).

This model is the first step in quantifying the domain of occupational instructor acquisition and conversion of subject-matter content into human (or machine) instruction. It is concluded that the approach originally proposed is feasible and models can be developed which have an immediate, practical application.

It is recommended that consideration be given these steps which follow logically:

a. refine the 49 feedback loops;

b. identify loops which do not now exist; evaluate them prognostically;

c. consider a number of mathematical techniques to quantify the flowchart model;

d. select promising mathematical techniques and synthesize a set of expressions;

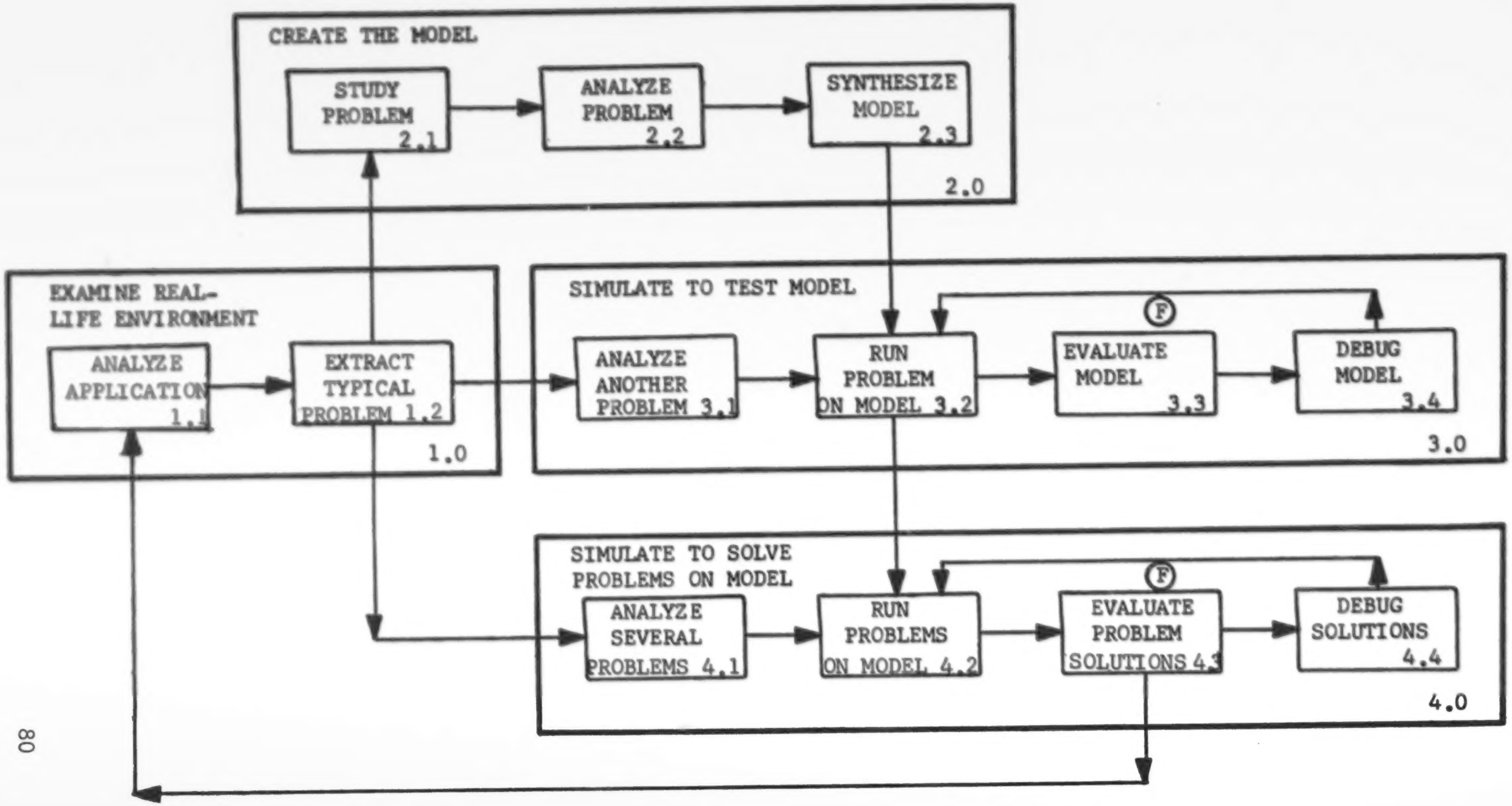
CREATE THE MODEL
STUDY PROBLEM 2.1
ANALYZE PROBLEM 2.2
SYNTHESIZE MODEL 2.3
2.0
EXAMINE REAL-LIFE ENVIRONMENT
ANALYZE APPLICATION 1.1
EXTRACT TYPICAL PROBLEM 1.2
1.0
SIMULATE TO TEST MODEL
ANALYZE ANOTHER PROBLEM 3.1
RUN PROBLEM ON MODEL 3.2
F
EVALUATE MODEL 3.3
DEBUG MODEL 3.4
3.0
SIMULATE TO SOLVE PROBLEMS ON MODEL
ANALYZE SEVERAL PROBLEMS 4.1
RUN PROBLEMS ON MODEL 4.2
F
EVALUATE PROBLEM SOLUTIONS 4.3
DEBUG SOLUTIONS 4.4
4.0

FIGURE 8

e. using both flowchart and mathematical models, in combination, represented by function (2.3) in Figure 8, simulate _to test_ the model (3.0);

f. using problems from real-life (1.0), simulate _to solve problems_ on the model (4.0).

g. apply the problem solutions (4.3) to real-life (1.1);

h. improve the model based on real-life experiences;

i. extend this technique of systems analysis and synthesis (anasynthesis) to other problem areas.

F. SUMMARY

The study identifies the Problem Area as the secondary school, and the Problem as the modification of occupational curriculums in keeping with variations in real-life. Specifically, the study is to determine the feasibility of developing a model or models which describe feedback signal paths from outside the school or school district to an occupational teacher.

System conceptualizations from 1914 to 1964 are carefully examined and more recent developments, between 1965 and 1967, in systems analysis and synthesis for education are delineated and evaluated for this study. A rigorous definition of 'feedback' is established. After examining graphic and mathematical models in education and training, it is concluded that the project should not rely solely upon what techniques are known and used by rank and file educators or educational researchers. Instead, attention is directed to systems theory and techniques in other disciplines.

The collection of data for this study is outlined and the analysis of the data and the synthesis of a flowchart model is presented. 49 closed-loop signal paths, each incorporating feedback, are traced and each is described using five characteristics: frequency, entropy, figure of merit, reliance, and recency. Each is evaluated. These are collectively related to occupational instructor performance.

The model reveals that certain feedback signal paths are considered critical while others may be ignored or discarded. Action is indicated for those which are critical.

The study states that the model synthesized is a high-fidelity analog of real-life, that it is a cybernetic model, that it is closed-loop, that it is a general model, that each closed-loop feedback path is identifiable in terms of five characteristics, that each loop can be measured in crude units, that instructor performance is a function of these five characteristics.

It is concluded that the approach originally proposed is feasible and the models can be developed which have an immediate, practical application. The recommendations are to refine the 49 feedback loops, identify loops which do not now exist and evaluate them, consider a number of mathematical techniques, select promising mathematical techniques and synthesize a set of expressions, using both flowchart/mathematical model combinations simulate to test the model. Using problems from real-life simulate to solve problems on the model, apply the problem solutions to real-life, improve the model based on real-life experiences, and extend this technique of systems analysis and synthesis (anasynthesis) to other problem areas.

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H. APPENDIXES

1: "HOW NEW CONTENT ELEMENTS ENTER INTO VOCATIONAL COURSES, IN ACTUAL PRACTICE"

by Dr. Leonard Nadler

This paper will attempt to deal with the task set forth in the letter from Dr. Leonard Silvern dated January 31, 1967 (Ref: 3. 1.3.62.3). It is based conceptually on the experience of the writer and as such does not reflect any single school system or a particular group of individuals. The dynamics of a particular situation can be expected to alter the elements discussed in this paper. In any single situation there may be some elements which are not included in the listing below. However, it is believed that these would be minimal in terms of having influence outside of that situation. This does not mean to imply that an innovation in a particular system does not have implications for our entire school system. Such innovations should be sought out and replicated. For purposes of this paper, however, the intent is to identify some actual practices.

1. The Teacher

The single most important source for introducing new elements is the teacher who must use the inputs. A teacher can also be expected to make inputs. For example, if the teacher has a particular area of expertese- an area of the curriculum with which he is more familiar or more comfortable, he is likely to keep up-to-date and be aware of the movements in terms of materials and equipment, as well as practices. Indeed, if the self-image of the teacher is identified with a particular vocational area he may purposely wish to identify the newer areas so that they may be reflected in his own life as well as his classroom teaching. Such a teacher will also be more sensitive to the newer trends in the field and therefore more open to the data which is available to him.

A change of instructors can significantly alter the curriculum content. A new teacher may bring with him a different area of expertese, interest, and self-image. All these can be expected to influence which elements of the curriculum he will emphasize and to which areas of change he is likely to remain more sensitive.

In both cases, the previous experience of the teacher would also be a significant element. As vocational teachers are usually required to have had actual experience, it can be expected that the work experience will effect the interest and tendency of the teacher to accept new curriculum inputs.

2. Suppliers of Materials and Equipment

A vocational program, particularly in the areas of electronics, drafting, and commercial art, must depend on the purchase of materials and equipment from outside sources, Accordingly, the suppliers of such equipment have salesmen who regularly visit the schools and endeavor to encourage the systems to purchase their newer tools and materials. In some cases, the teacher either recommends the actual purchase or has the authority to make the purchase within certain budgetary restrictions. The newer tools and materials purchased, in such a situation, will reflect the interest of the teacher as tempered by the ability of the salesman to influence the purchaser.

In addition to supplying the materials and tools, the salesman is usually expected to also provide other fringe benefits to the purchaser. These may consist of specially prepared reading materials on current trends, or the verbal sharing of what the salesman has observed in other school systems or in contact with other purchasers.

At times, a supplier organization may actually place new equipment or materials into a school system for demonstration purposes. When a system accepts these, they are also accepting new inputs to their curriculum. It can be expected that the new materials and tools, as well as methods, will reflect what the supplier feels are the needs of the general market including non-school agencies. The result is a cross-feeding, through the supplier, of the real world outside the school.

3. Professional Organizations

As with most teachers, it can be expected that the vocational teacher will be a member of one or more of the organizations concerned with his area. He will usually be a member of an organization that is primarily educationally oriented such as the National Education Association or one of the many organizations in special subject matter areas. In addition, he may also be a member of broader organizations such as the American Society for Training and Development which includes persons concerned with job training, but most of the membership is drawn from those who are outside the secondary school system. He may also be a member of an organization of professionals in a particular area who are employed in the field, but not in a teaching capacity.

Through the myriad of professional organizations competing for his attention he will receive a constant bombardment of literature informing him of the newer methods and materials as well as information related to the job market. If he is a member, he will receive at least one publication on a regular basis. Many of the society publications are concerned with sharing innovative practices, as well as the more pedestrian practices among its membership. Within the publications there may be advertisements from those who supply materials and equipment "to the trade." These ads can be expected to influence the teacher in terms of their indications of the newer materials and tools as well as the practices related to them.

If the teacher can attend the meetings of the professional organizations he will receive further inputs on the newer developments. Some organizations have local meetings held on a periodic basis, while others rely to a great extent on a annual function. In either case, these are usually seen as opportunities to learn what others are doing in the field, through the organized program as well as through the informal contacts. Annual meetings usually have some form of trade fair or other opportunity for exhibitors to show their latest tools and materials.

Some professional organizations have assumed the role of setting standards for their members. This may include some standards for materials, or what constitutes certain kind of inspection procedure. These standards may relate to some of the materials which would be used in the classroom.

The effect of professional organizations in influencing curriculum will be strongly affected by the perception of the organization by the teacher. Generally speaking, the organization can influence the teacher only to the extent that the teacher is prepared to accept such an influence. Once accepting it, however, the teacher will find that the content of his curriculum will be changed.

4. Parents and Community

The parents and the community might be seen more as a potential than an actual force. That is, the parents in the U.S. have not been noted for their impact upon the curriculum content except in some areas where there may have been political or moral implications. As vocational areas are usually not quite so controversial, the involvement of the parents can be expected to be minimal. However, there have been cases where this has been different. For example, then parents have helped their children with their projects for science fairs, the interests and experiences of the parents have introduced new materials and concepts which were not previously found in the curriculum.

Community influence can be felt where the equipment needed is costly and allocation of funds becomes a local political issue. There have been very few cases of this, but the force does exist.

5. Graduates

The graduates of the school provide an input on the changing requirements of the job market, They also provide data on some of the newer materials, methods, and practices which they encounter in the world of work. Often, the graduate appears to seek out the differences in order to criticize the school system for its antiquated methods, materials and practices.

The criticisms of the graduates are usually directed toward the school system through his associates who are still in school, as well as in private and informal conferences with his former teachers. It is rare that any organized system exists for obtaining data from the graduate which could prove a positive force in the curriculum.

6. School Placement Officers

Most vocational schools have some form of placement for their students. Although such offices may not be staffed by trained professionals in the field of placement they usually have dedicated individuals who are learning as they provide the service. These placement persons are in direct contact with the job market and know the marketable skills which are being sought. Frequently, there is no organized method for their experiences to be funnelled back to the teacher and there is no direct way for them to effect curriculum. However, in their informal contacts with the teachers, they do make some inputs which provide new content elements.

7. Students.

Theoretically, students should be able to have a direct influence on the curriculum. In the more traditional areas (e.g. English, Social Studies) such influence is minimal if it exists at all. In the vocational area, the student enfluence is much greater.

When a vocational student has an interest or hobby which relates to the curriculum, he is more likely to pursue it to the point of being familiar trends, materials, and equipment. Through his outside projects as well as his school-directed projects, such a student will provide additional data which can introduce new content into the curriculum.

A vocational student may also be strongly influenced by graduates, particularly recent graduates who are closer to his peer group. The actual job experiences of such graduates may cause the student to raise additional questions which will be met by changes in course content and materials.

8. Business and Industry

For a variety of reasons, private business and industrial firms make donations of equipment and materials to school systems. In some cases, this may be prompted by a feeling of social responsibility on the part of the organization. In other instances, the motivation may be to assist the school in its efforts to prepare their students for the job market. No matter what the motivation, the donation of the equipment will most likely affect the curriculum content as it relates to the items being donated. The donation may serve to solidify the curriculum- to reinforce that which is already there. Another donation may introduce materials which the school system usually cannot budget for, or does not have the fiscal ability to procure.

On a less tangable level, field trips to companies can affect curriculum content. Where the classroom instruction and/or materials is at variance with what the student observes during a field trip, some accomodation must be made. If the differences are too great, this may result in a reduction of field trips or a more careful selection of those places to be visited. Where the school system (i.e. teacher) is prepared to cope with the differences, the effect may be seen in curriculum content.

Many school systems sponsor career days, wherin the potential employers visit the school and explain their organization and job requirements. When the requirements are openly verbalized, and where they are different from the existing curriculum content, it can be expected that new content elements may result.

General Statement

In terms of hierarchy of the above, there is a definite split. By far, the most effective and frequent manner by which new content enters the curriculum is through the teacher. In any school system, this is by far the most significant point of entry.

After the teacher, the rank order is much less clear. The next force would be the professional organizations in that they are in the position of making the most impact on the teacher and therefore on the curriculum content.

The third force, but close behind the second would be the suppliers. They too can directly influence the teacher and therefore the curriculum content.

E
T
CAPABILITY AND INTERESTS

PRODUCING

- Job, Task and Behavioral Analyses
- Job and Task Syntheses
- Courses and Curriculums in Programmed and Conventional Format
- Performance and Written Achievement Tests
- Technical Manuals and Texts
- System Studies

DESIGNING

- Instructional Systems for Employee and Customer Training
- Instructional Education Systems
- Simulators and Training Simulation
- Computer-Assisted Instruction (CAI)
- Man-Machine Systems for Complex Learning

CONDUCTING INTENSIVE COURSES

- Instructional Programming
- Designing Instructional Systems
- Systems Analysis, Synthesis, Anasynthesis
- Methods of Classroom Instruction
- Media Instrumentation
- Computer-Assisted Instruction (CAI)

CONSULTING

- Short-Term, Single Project Consultation
- Long-Term, Retainer Consultation
- Proposal Preparation
- Research Design
- University-Industry Joint Projects
- Market Analysis of Instructional Media

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